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AGENTS' AND INSPECTORS POCKET-BOOK

OF

FIRE PROTECTION

BY

GEO. VELTEN STEEB

Associate Member National Fire Protection Association

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PREFACE

Since the publication of my "Fire Insurance Agents' and Surveyors' Pocket-book of Information" in 1896 many new rules and requirements have been adopted by the National Board of Fire Underwriters, and much that is new in the province of fire protection has been learned by investigation and observation, so that it seems proper at this time that I revise my early book and bring it up to date in all respects, and this is what I have sought to do in this present book, trusting that my efforts will meet with the same favorable reception that my previous book had.

This book has been written with the idea of presenting existing conditions and their remedies, and not with the purpose of presenting dry rules and specifications, nor with the purpose of instructing manufacturers what class of construction is necessary for certain appliances; hence the rules pertaining to the construction of various machines and appliances have not been incorporated herein unless deemed necessary for the needs of inspection, but how the machines or appliances should be set, where they should be located and all the other necessary information which an inspector or special agent should have in order to be fully posted as to how a thing should be, and that he may be able to clearly answer all questions that may be asked him in regard to arrangements, locations, etc., of the various appliances, are treated here in a readable, non-technical and, I hope, understandable manner.

Every subject cannot be specifically treated in detail, but each subject has been handled in such a way that it is believed that any conditions arising under it can be properly treated from the information here given.

The information given within is from the Rules and Requirements of the National Board of Fire Underwriters, and from the experience gained by a practical field service with all classes of insurable risks in all the States and Canada, East of the Rocky Mountains, during a continuous period of over sixteen years.

MAY, 1902. G. V. S.

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CHAPTER I.

CONSTRUCTION

There is no such thing as fireproof construction. There is a class of construction termed "fireproof," but its analogous (so accepted) term, "superior," more properly expresses what is meant by this class of construction. Wood will burn, iron and steel will bend and give way under the action of heat, and they also tend to destructively contract when they are overheated and have cold water suddenly thrown on them; stone tends to disintegrate under the action of heat and water, and buildings have not yet been built of fireproof terra cotta or brick, nor of glass, and so it is that there are no actual fireproof buildings. But there are buildings so constructed that the liability of their destruction by fire is practically reduced to a minimum; but it is not intended to suggest that the contents of such building are not liable to burn. A "fireproof" or "superior" construction is to a great extent thought to imply that the contents will not burn; this idea is as silly as it is impossible. The idea in this class of construction, termed "fireproof," is to reduce the liability of a fire commencing in such a building from spreading, not only to some other building, but from the location in which it starts to some other part of the building, and it has been demonstrated that this result has been reached to a very great degree. But the water and smoke damage in such a building cannot be entirely eliminated. The water damage can be reduced to a considerable extent by pitching the floors and providing drains for each floor, so that the water on one floor will not necessarily run down to the floor below.

In "mill" construction there has been reached a high degree of construction which, while not fireproof, as all of the interior is of wooden construction, still is of such a class that a fire does not easily destroy the wood, and from the fact that there are no concealed spaces nor draught spaces, a fire cannot develop nor spread rapidly, and the chances of extinguishment are very much increased. Buildings of this construction are never built as high as are buildings of the so-called "fireproof" class, but for the purposes of manufacturing plants they are preferable.

"Hollow-spaced" construction is, of course, the poorest class of construction from a fire insurance standpoint.

CONSTRUCTION.

For general descriptive purposes construction can be divided into three classes, i. e., "fireproof" ("superior"), "mill" ("slow-burning"), and "hollow-spaced."

"FIREPROOF." ("SUPERIOR CONSTRUCTION")—The characteristics of this class are a bridge construction of steel; a framework for walls and floors, riveted together and making a self-sustaining rigid frame. The walls, preferably of brick, are built over and around the skeleton, in some cases being self-supporting and in others receiving support from the framework of steel. The floors are usually made of terra cotta arches sprung in between the steel girders and thoroughly covering them, and having a top finish of concrete on top of which the flooring of tiles or narrow wooden flooring is laid.

The partitions throughout are of fireproof brick or tile; the stairs and elevators are in hallways cut off from the remainder of the building by fireproof partitions; the framework, and all parts of the stairs and elevators being of steel and stone.

The exposed metal at the stairs and elevator should be the only exposed metal in the entire building, the posts being covered with fireproofing the same as all other parts of the construction steel.

The roofs are of the same construction as the floors with the exception that they have no wooden flooring top finish.

"MILL," or "SLOW-BURNING."—The main idea in this class of construction is that there shall be no hollow or concealed spaces whatever, and that there shall be no openings in the floors.

Walls are of brick, 12 inches at the top floor and 4 inches thicker at each second floor for outside walls, and for division, party or cut-off walls 4 inches thicker than the outside walls at each floor: all exposed outside walls and all party walls to be 3-foot parapet, i. e., to be 3 foot higher than the contiguous roofs; division walls to be corbeled sufficiently so that they will extend beyond the outside line of the roof overhang or cornice.

Stairways and elevators to be in brick towers or shafts, the walls of which rise 3 feet, at least, above the roof of the building.

The roofs are of the same construction as the floors excepting that they need be only 3 inches thick, and covered with gravel, metal or approved composition.

The floors are double, the first layer being of 3-inch splined planking and the top flooring one-inch matched boards with two thicknesses of waterproof paper between them. The boards and planking should preferably be laid diagonally. The beams are of solid wood supported by ledges in the walls, a proper corbeling or iron wall plates, and by wooden posts; the beams must be cut on a splay at the wall bearings so as to make them self-releasing, in order to prevent the walls being pulled down in case of a beam falling. The posts are placed one over the other throughout, and are provided with cast iron caps pintles and base plates, the beams setting on the plates and being self-releasing.

The outside wall top finish should be the roof overhang, un boxed, or a brick, stone or terra cotta cornice.

Stairways may extend through floors between two floors, but they must be of incombustible material and must be enclosed in fireproof enclosures of brick, terra cotta, concrete, or iron frame with metal lathing plastered on both sides.

All communicating openings in walls to be provided with double-standard tin clad fire doors or shutters, and all exposed openings to have standard tin clad fire shutters on them. All shaft, belt, flue and trunk holes to be as small as possible, either by being bricked up or by being provided with standard fire shutters or metal hoods.

For additional rigidity and strength, girders can be placed between the floor beams, but these girders must rest in iron stirrups at their ends.

The following variations from these rules are found to a considerable extent in so-called "mill" or "slow-burning" construction factories: Elevators inside the building with automatic traps at each floor; inside stairways enclosed in wooden partitions or with automatic acting traps at the upper landing of each flight of stairs, the material of the stairs being wood; open belt holes in floors; outside walls, pilasters with large windows between.

"HOLLOW-SPACED." CONSTRUCTION.—This class includes dwellings, the ordinary stores, business blocks, office buildings, hotels, etc., whether built of brick, stone, or wood, although there are now many exceptions in the larger cities in the construction of office buildings, large stores, and other business blocks and some hotels.

In this class of construction the interior finish is of laths of wood or expanded metal, wire netting covered with plaster, or of wood ceilings; the floor construction being of wooden joists with single wooden flooring above them and laths and plaster, or, in some comparatively few cases, stamped steel on the under side to form the ceiling for the floor below, thus leaving hollow enclosed spaces between the flooring and the joists and the ceiling below; the walls are finished in a similar way with laths and plaster and hollow concealed spaces are formed between the walls and the lath and plastering; these spaces in a majority of cases running from floor to floor without any breaks from the lowest to the highest story of the building.

The main point to be looked after as an improvement in this class of construction is the cutting off of draught spaces, i. e., continuous concealed spaces in the floorings and walls. In the floor spaces this can be done by setting "stops" or "breaks" in the horizontal concealed spaces; these "stops" can be of planking, which same when properly set will cut off any rush of air or draught. In the walls, the building laws of New York city call for all furred walls to have a course of bricks above the under side and below the upper side of each tier of floor beams, projected out the thickness of the furring, to more effectually prevent the spread of fire from floor to floor in this hollow space; in order to remedy this defect where already in the construction, the space between the flooring and the wall itself (not to finish of the wall, but the wall itself) should be filled in so as to absolutely cut off the continuous hollow space at this point; this will prevent draught and retard the progress of fire from floor to floor at this place. While a building is in course of construction "breaks" can easily be made by filling in spaces at floors with old bricks and mortar held close against the walls by confining strips set in between the joists.

A building well finished with plaster is better than one with a wood inasmuch as there is not so much material to carry a fire or for a fire to feed on.

The "hollow-spaced" construction is the worst form of construction.

WALLS.—Walls should preferably be "blank," i. e., without any openings whatever in them.

Independent walls with exposed openings should have the openings protected with standard fire doors or shutters, wired glass or prism glass.

Party or division walls having openings in them should have the openings protected with standard fire doors.

All walls, wherever possible, should be fire walls.

A fire wall is one of stone, brick, or terra cotta, extending 3 feet above the contiguous roofs' level, i. e., parapet, stone, terra cotta, or cast iron coped, "blank" or with all the openings in it protected by standard fire doors or shutters, and with a proper thickness of wall (a "proper thickness" to be judged not only by the height of the building, but also by the uses of the rooms or buildings on each side of the wall where buildings are using the wall as a party wall, or where the wall is a division wall); if the fire wall is a division wall, or an independent wall exposed to other buildings, it should be corbeled a sufficient distance so as to extend beyond the line of the cornice of the building.

All stone or brick division or party walls, and all stone or brick exterior walls directly exposed to outside buildings of less or equal height, or of greater height (when not over 2 feet), should be raised from 2 feet to 3 feet above their roofs' levels, thus making parapet walls, and should be capped with stone, terra cotta, or cast iron.

Partition walls should, as far as possible, be of brick, tiles, plastered wire netting, or single boards unceiled; where wood scantling is lath and plaster it should be filled in between the scantling with brick.

Where wooden buildings have sides or ends exposed to other buildings, or to other parts of the same building, the exposed surfaces should be covered with some fire-resisting material following all lines and angles of the walls.

Concealed spaces in walls should be avoided as much as possible. Where plastered brick or stone walls are desired, the plaster should be put directly on the walls; where it is not possible to put plaster directly on the walls, wire netting or expanded metal laths should be used; where a wood covering is used, the wood should be directly against the walls, following all lines and angles of the same; wooden laths should be avoided.

THICKNESS OF WALLS AS PER LAWS OF NEW YORK STATE, AND RECOMMENDED BY THE NATIONAL BOARD OF FIRE UNDERWRITERS, JUNE, 1893.

35 feet to 50 feet high.	12 inches (dwellings, etc., 26 feet or less between bearing walls).
50 " " 60 " "	12 inches above basement (dwellings).
60 " " 75 " "	16 " for 25 feet up: 12 inches above.
75 " " 85 " "	20 " for 20 " : 16 " up to 60 feet: 12 inches above.
85 " " 100 " "	24 inches for 35 feet up: 20 " up to 75 feet: 16 inches above.
100 " " 115 " "	28 inches for 25 feet up: 24 " up to 50 feet: 20 inches up to 90 feet: 16 inches above.
Over 115 feet high	Each additional 25 feet in height or part thereof next above curb should be increased 4 inches in thickness, the upper 115 feet of wall remaining as above.

Non-bearing walls in dwellings, etc., may be 4 inches less in thickness to a minimum thickness of 12 inches.

WALLS 25 FEET OR LESS IN WIDTH BETWEEN WALLS OR BEARINGS (FACTORIES, WAREHOUSES, STORES, STABLES).

Up to 40 feet high	12 inches.
40 to 60 " "	16 " for 40 feet up: 12 inches above.
60 to 75 " "	20 " for 25 " up: 16 " "
75 to 85 " "	24 " for 20 " up: 20 " up to 60 feet: 16 inches above.
85 to 100 " "	28 inches for 25 " up: 24 " up to 50 feet: 20 inches up to 75 feet: 16 inches above.
Over 100 " "	Each additional 25 feet in height or part thereof next above curb should be increased 4 inches in thickness, the upper 100 feet of wall remaining as above.

Walls over 25 feet in width between walls or bearings. (Factories, warehouses, stores, stables.) Bearing walls should be 4 inches more in thickness than specified above, for every 12½ feet or fraction thereof that said walls are more than 25 feet apart.

All buildings that are over 105 feet in depth, without a cross wall, or proper piers or buttresses, shall have the side or bearing walls increased in thickness 4 inches more than above that the said walls of buildings are over 105 feet in depth.

Factories, Warehouses, Stores, over 25 feet in width between walls, in which there are brick partition walls, or girders supported on iron or wooden columns, or piers of masonry, the partition walls or girders shall be so placed that the space between any two partition walls or girders shall not exceed 25 feet, In case iron or wooden girders, supported by iron or wooden columns, or piers of masonry, are substituted in place of brick partition walls, the building should not exceed 10,000 feet area on the ground floor, except in case of fireproof buildings.

Curtain walls of brick, built in between iron or steel columns, and supported wholly or in part on iron or steel girders, shall not be less than 12 inches thick for fifty feet of the uppermost height thereof, and every lower section of fifty feet shall have a thickness of 4 inches more than is required for the section next above it down to the tier of beams nearest to the curb level.

GENERAL TABLE OF THICKNESS OF SOLID BRICK WALLS.

	Basement	1st Floor.	2d Floor.	3d Floor.	4th Floor.	5th Floor.	6th Floor.	7th Floor.	8th Floor.	9th Floor.	10th Floor.	11th Floor.	12th Floor.
For 1 story	12	8											
" 2 stories	16	12	12										
" 3 "	16	16	12	12									
" 4 "	20	16	16	12	12								
" 5 "	24	20	16	16	12	12							
" 6 "	24	20	20	16	16	12	12						
" 7 "	24	20	20	20	16	16	16	12					
" 8 "	28	24	20	20	20	16	16	16	12				
" 9 "	28	24	24	20	20	20	16	16	16	12			
" 10 "	28	24	24	24	20	20	20	16	16	16	12		
" 11 "	32	28	24	24	24	20	20	20	16	16	16	12	
" 12 "	32	28	28	24	24	24	20	20	20	16	16	16	12

In place of solid brick walls, the walls above the first floor can be of heavy brick piers 8 feet to 10 feet apart between centers with large windows between the piers; any intervening spaces to be filled in with brick; but this construction should not be used in building of more than 3 stories in height when used for all walls, but where used for only one wall, between bearing walls can be carried up to 6 stories.

ROOFS.—A gravel roof made of small round stones laid on properly prepared and spread good coal tar is a most desirable one for roofs having a slight pitch, and is, to a certain extent. fireproof.

Composition roofs are now made in such a manner as to practically eliminate the old objection to them, that is, the liability of their cracking; the materials used and the way of mixing them as well as the manner of laying them is now such that many of these roofs are lasting and, to a decided extent, fireproof. Where acid fumes, such as destroy metal, are in evidence, these roofs are especially desirable.

Trinidad asphalt and asbestos roofs withstand great heat, and are a good type of roofing for buildings subject to constant heat and acid fumes, besides being lasting and not liable to become expensive through repairs.

Tin and copper make the best sheet metal roofs, but they should be well laid and soldered.

Sheet iron does not make a lasting roof, as it is easily affected by the weather and soon goes into holes.

Metal roofs should not be used where there is any probability of acid fumes attacking them, as under such conditions they will soon deteriorate and become worthless. They should be kept thoroughly painted with iron oxide paint to prevent rusting; lead paint will not adhere as firmly and securely as the iron oxide, and thus an additional expense is incurred in keeping the roofs in a good painted condition where the lead paints are used.

Slate is liable to break, and so make apertures through which sparks can lodge in the wood sheathing under the slate; this objection to these roofs can be overcome to a great extent by laying the slate in mortar.

Cotton duck for roofing, soaked in water, and painted with white lead and linseed oil before being thoroughly dry, and after drying painted with several coats of white lead and fireproof paint, and then covered with sand, makes a good waterproof and practically fireproof roof.

Through the action of age, water, heat, and cold, shingle roofs curl, warp, crack, and rot, and thus lodgment holes for sparks are formed; they also present a large inflammable surface to exposure. Such roofs should be removed or some steps taken to reduce the hazerd: as, for instance, they can be painted with several coats of fireproof paint, or the shingles can be laid in lime mortar (this tends to hold them in place and prevents their warping).

Brick arched roofs or fire tile roofs on properly protected steel girders are from the fire hazard point of view the best roofs.

Barn, mansard, and hipped roofs are not desirable on account of the increase of exposed surface, additional weight, and the joisted and general class of construction.

CORNICES.—Brick, stone, and terra cotta are especially desirable on account of their forming an integral part of the building and being non-combustible.

Cast iron when entirely disconnected from the cornice of any other building is not objectionable, but where it is continuous with and forming one cornice with that of contiguous buildings it is a weak feature, from the fact that by the falling of the cornice of the adjoining building the cornice on the other buildings would be seriously damaged; also, if there are openings leading into the cornice from the building, in case of fire a suction chamber for carrying the fire from building to building is immediately formed, hence under these conditions this form of cornice is not very desirable.

An open, unboxed wooden roof overhang is the best class of cornice for "slow-burning," "mill," or any other form of construction for factory purposes where brick of terra cotta cornices are not built.

Boxed wooden cornices, especially where exposed to other buildings, or where continuous with similar cornices of contiguous buildings, constitute a very weak and hazardous point, and should be removed or made open wherever possible.

All wooden cornices should be preferably of open construction.

Where hollow metal or hollow wooden cornices are continuous with the cornices of other buildings, a "break" in the cornice should be made at each wall, said "break" to be made of brick, heavy iron, wood standard tin clad, or asbestos partition entirely filling the full open end of the cornice. These "breaks" or "stops" will prevent the fire in one building communicating to a contiguous building through the opening in the cornice.

SKYLIGHTS.—Frames should preferably be "hipped," i. e., the sides at an angle so that the topmost point will form an angle and thus be entirely different in form from the flat style.

The glass should be thick, wired glass or ribbed glass.

Area should not exceed 50 feet when the frame is of wood; when the area is in excess of this the entire frame should be of iron.

All flat or hipped skylights should be protected by wire netting of a mesh not larger than ½ inch and the wire should not be less than No. 12; this netting should be in a rigid iron frame supported by iron standards from 6 to 12 inches high.

Monitor or lantern skylights should have the same kind of roofing as the main roof.

FLOORS.—Under all conditions, hollow fireproof brick or tile floors supported by iron or steel girders fully covered by tiles or fire-brick, and covered by a cement, or a hardwood flooring, or brick-arched floors, or "slow-burning" constructed floors, are to be desired.

Wherever any heavy work or trucking is done, wooden floors should be double.

Where any specially hazardous processes are carried on (as in foundries, varnish works, burner rooms in acid works, hot rooms, japan dry rooms, boiler rooms, etc.), the floors should be of earth, cement or concrete.

All floors should be tight against walls, allowing no air space between the walls and floors.

Where iron posts, beams, girders, etc., are used, they should be fireproofed by thoroughly encasing them in fireproof bricks or tiles, or covering them by layers of asbestos or mineral wool and cement held in place by wire netting, or by some other approved method.

Floor beams should at least have a bearing at each end of 4 inches.

The butts or ends of all beams and rafters entering a brick wall should be cut on a splay of 3 inches in their width, so as to make them self-releasing.

There should be at least 4 inches of brick between the ends of all wooden beams, rafters and joists entering the same brick or stone wall from opposite sides.

Ends of wooden beams, rafters, and joists should not be within 1½ inches of any fire flues or chimneys; where such space (1½ inches between beams, etc., and flues, etc.) is to be closed, concrete, cement, or asbestos should be used as a filler.

Floors should be always be kept in good repair and all unnecessary openings closed over.

All floor boards should be planed and finished on both sides and tongued and grooved.

All wooden posts, beams, rafters, and joists should be smooth planed and finished.

CHIMNEYS.—Should be of brick.

In dwellings no woodwork should be closer than 4 inches to the chimney.

All chimneys should be smoothly plastered on the inside with cement, or have all joints struck smooth on the inside, or be lined with burnt-clay, terra cotta or vitrified pipe.

No chimney should have a thickness of brick of less than 8 inches, and chimneys of furnaces, boilers, bakers' ovens, large cooking ranges, laundry stoves, and other heating appliances generating much heat should be of greater thickness.

All chimneys or smoke flues should extend at least 3 feet above a flat roof and 2 feet above the ridge of a peaked roof.

No chimney should be started or built on any floor, wood-supported shelf, or wooden beam of the building.

Brick flues not starting from the foundation in a brick or stone building should be securely built in to the walls into which they are hung. In no case shall a chimney rest on any flooring with out a footing of masonry or iron supported by iron beams having a secure bearing on masonry or iron at each end.

Chimneys of iron cupolas of foundries should extend at least 10 feet above the highest point of any roof within a radius of 50 feet.

Chimneys in frame buildings, when not built up from the ground, should rest on masonry supported on separate wooden or iron supports running from the ground up.

All smoke flues of smelting furnaces or of steam boilers, or other apparatus which heats the flues to a high temperature, should have double walls, with an air space between them, the inside 4 inches of fire-brick or fire-clay slabs or blocks laid in fire-mortar to the height of 25 feet from the bottom.

STOVE and SMOKE PIPES.—Where passing through roofs, floors, wooden partitions, studding partitions, or any inflammable materials should be surrounded by a double metal collar (with at least 3 inches of air space between the two parts, and with holes for ventilation), or by a soapstone or burnt-clay ring not less than 2 inches in thickness and extending through the partition.

No stovepipe should enter a chimney within 12 inches of wooden floors, ceilings, or partitions unless there is a metal shield, ventilated on both sides, between the pipe and wood, when the distance may be reduced to not less than 9 inches, or, unless where the wood is covered with asbestos and jointed tin (standard clad), following all lines and angles of the wood, where the distance may be 2 inches.

No floor beams or joists should come within 4 inches of any heat flues.

CEILINGS.—Ceilings should be left open whenever possible.

Wooden lath ceilings are particularly objectionable. Where plaster is desired for a ceiling, wire netting or expanded metal laths should be used instead of wooden laths.

Where a finished ceiling is wanted, a good ceiling is made of stamped steel plates.

Wooden ceilings present large feeding surfaces for flame, and when they are finished with oils or varnishes are very inflammable; hence they should be installed as seldom as possible.

No ceiling should be closed over any heating apparatus where it is close to the ceiling, or where a high degree of heat is used.

All closed ceilings should be removed wherever possible.

Broken ceilings must be removed or thoroughly repaired.

ELEVATORS, DUMMY, and HOISTWAYS.—Should be in brick shafts (preferably outside of the building), the walls of which should rise at least three feet above the roof; standard fire doors should be on each opening of the shaft.

In a building with a tower, the elevator should be in the tower.

Hatchways inside of buildings, and not enclosed, should be provided with automatic traps which open and close as the elevator is passing through the floor, or have tight-fitting traps at each floor held open by cords having fusible links in them exposed to the open hatchway; these latter traps should be so arranged as to be closed from any one floor independent of the fusing of the links.

Wooden enclosure elevator shafts are not desirable, although they are better than having an open hatchway without traps; the doors and partitions of such shafts are very apt to become broken or in some state of disrepair and the shaft then becomes merely a large draft chimney in effect.

No openings other than the doorways should be in any elevator shaft, and the doors on each opening should be always closed when the doorway is not in actual use.

Windows in elevator shafts should be of thick glass, set in permanently closed frames.

Trap doors must fit tight and be of not less than 1¼-inch sound, well-seasoned matched boards with battens.

AUTOMATIC ELEVATOR TRAPS.—(Rules of the National Board of Fire Underwriters): Open elevator shafts and hatchways shall be provided at each floor opening with a trap door which opens and closes as the elevator passes. If the floor is of ordinary construction, or not more than 1¼ inches thick, the trap door shall be made of 1¼-inch sound, well-seasoned, narrow matched boards with battens screwed on, but if the floor is of mill construction, or more than 1¼ inches thick, the trap door shall be as just described and shall have standard lock-jointed tin covering, as required for fire doors, on the under side, the tin extended over all edges including hole, if any, for cable, and nailed on the upper side of door. The hole for cable, if any, shall be as small as possible. When the trap door is closed it shall extend beyond the opening on all sides. Elevator left at a landing shall not be accepted in lieu of a trap door.

A trap opened and closed by the moving elevator is regarded as distinctly superior to other devices and should be generally used. However, if not employed, owing to high speed of elevator or other cause, automatic traps should be placed at each floor. They should be constructed as above, secured by stout wrought-iron hardware attached by bolts; be held open by a fusible link located on shaft side of door; be actuated from hind by heavy spring which upon fusing of the link will p trap beyond a vertical position so it will close by gravity; and kept closed except during working hours.

Dumb-waiters, barrel chutes, box chutes, small hoistways goods or papers and all similar floor openings should be trapp or have tight-fitting wooden enclosures reaching from floor floor between them.

WELL-HOLES.—These constitute a very weak point a should be boarded over tightly whenever possible.

Where the well-hole is necessary, it should be covered with heavy glass skylight in an iron frame on each floor, and whe this is not desirable, close-fitting automatic-working wood traps or asbestos curtains should be provided; these can be mad to be automatic in closing by arranging them in such a mann that their own weight will close them and then having them hel open by cords having fusible links incorporated in their length which shall stretch across the entire length of the well-hol with the fusible links directly in the well-hole opening; by th melting of a link the cord will separate and thus allow the tra or curtain to close; traps or curtains should be kept closed a much as possible.

Enclosed well-holes constitute bad draft chimneys, especiall where the well-holes on only one or two floors are enclosed and on other floors open; these should be closed or trapped whenever possible.

STAIRWAYS.—Should, wherever possible, be in brick shafts or towers, the walls of which rise 3 feet above contiguous roofs and have standard fire doors on their openings.

The stairway frames, treads, etc., should preferably be of some incombustible material.

Stairways inside of buildings should not, if possible, be one directly over the other, but should be in different sections of the floor for each flight; they should be enclosed in brick, cement, or terra cotta partitions, or where this is not possible in partitions of matched boards or splined planks of a minimum thickness of 2 inches. Fireproof partitions to have standard fire doors on each stairway, and wooden partitions to have wooden doors of not less than two thicknesses of matched boards of a minimum thickness of ¾ inch each. Doors should preferably be at the bottom of each flight.

Where stairway partitions are used, the stairways themselves must be made tight so as to have no draughtways through them.

Automatic trap doors for stairways.—(Rules of National Board of Fire Underwriters): If the floor is not more than 1¼ inches thick, the door shall be made of 1¼-inch sound, well-seasoned, narrow, matched boards with battens screwed on. If the floor is more than 1¼ inches thick, the door shall be as just described, and shall have a standard lock-jointed tin covering, as required for fire doors, on the under side, the tin extended over the edges and nailed on the upper side of the door. Hinges to be of heavy wrought metal with straps extending well onto the door. To be balanced with a weight on a cord running over double pulley on wall, a fusible link being inserted at point where cord is fastened to the door, so that door will close automatically in the event of fire. To be provided with a wrought-metal bow high enough to form a stop which will prevent the door being raised to a vertical line, thus keeping it in such position that it is sure to drop when link melts. Bow to be securely fastened to the upper side of the door so that it will serve as a handle.

Stairway Enclosures—Buildings of Ordinary Construction.—(Rules of National Board of Fire Underwriters): Stairways to have separate enclosure for each flight, not less than 1½ inches thick, made tight and kept in repair. If approved fireproof material is not used, enclosure to be made of two thicknesses of matched boards, or of tongued and grooved or splined planks. (Double boarding is preferable to single planking, as it is not so liable to warp and open up at the seams.) A door must be provided at each flight, preferably at the bottom; the doors to be not less than 1½ inches thick and unless standard iron or tin-clad, to be constructed of two thicknesses of matched boards or of tongued and grooved splined planks. Heavy wrought-iron hinges, latches, and catches to be attached by bolts. Doors to be kept closed and latched when not in use. It is preferable to attatch a spiral spring to all doors to keep same closed automatically, the doors which are kept open during working hours to be held so by a hook attached to a fusible link located as high on the door as convenient.

Stairway Enclosures—Buildings of Fireproof or Mill Construction.—(Rules of National Board of Fire Underwriters): Stai openings in buildings of such construction not "cut-off" in fireproof shafts are a violation of a most prominent principle of sucl construction, but when they do exist they should be enclosec by fireproof material.

CHAPTER II.

SPECIAL CONSTRUCTION AND NOTES.

BOILER HOUSES AND ROOMS.—While as a rule boilers are apt to be properly placed in new buildings and plants, it is quite a common thing to find boilers and breechings in poorly ventilated places, close to woodwork and not properly set in many buildings; especially so in risks where the boilers are only used for heating or for running light power plants.

They should be of brick, not contiguous to main buildings, or if contiguous, with fire-walls at main buildings in such risks as grain elevators, oil works, chemical works, where specially hazardous processes are carried on, varnish works, paint works, woodworking plants, saw mills, flour mills, cotton mills, woolen mills, rubber works, etc.

Should only be inside of such classes of risks as mercantile, light manufacturing buildings, rolling mills, etc.

Detached boiler houses should be of brick, with unfinished walls, earth or cement floors, roof high enough to give good ventilating space above the boilers, roof provided with a good sized ventilator, and the walls of the boilers should be independent of the boiler house walls.

When adjoining other buildings should be as per above, with the division or party wall a fire wall.

All woodwork directly exposed to any boiler, steam dome of boiler, breeching or flue, must be covered with sheet asbestos overlaid with tin (standard clad), both closely following all lines and angles of the woodwork. A metal shield with air spaces on both sides affords some protection, but is not generally efficient for the purpose of protecting the wood from the action of the heat.

(See also Chapter IV.)

Stacks should preferably be of brick, detached from all buildings.

Iron stacks must be detached from all buildings.

Where iron stacks, whether from boilers, furnaces, heaters, forges, etc., pass through slate, metal, gravel or composition roofs, a clear space of 8 inches should be between the stacks and roof, and where the roofs are of shingles the clear space should be 12 inches. This clear space can be covered with a metal hood.

All stacks at electric light and power plants, cotton mills, woolen mills, grain elevators, oil works, etc., must be outside and disconnected from the buildings.

ROOF HOUSES for any purposes whatever, whether over elevators, for sulphur or other bleaching, etc., should be of fire-brick or tiles, or of planking covered with lock-jointed tin.

HOODS.—Wood or metal hoods, 3 inches to 6 inches deep, should be hung from ceilings around all openings in floors, so as to prevent as much draft as possible between floors.

WASTE CHUTES.—Should be of brick, extending 3 feet above the roof, preferably outside of the building; but if wholly within the building the tops should be fireproof. Standard fire doors should be on all openings.

TEXTILE MILLS PICKER ROOMS.—Should be in buildings independent of the main building, and cut off from them by fire walls.

Under some constructions picker rooms are now being cut off from the remainder of the buildings by brick walls extending to the ceilings of the picker room only, and with the ceiling of the picker room made of cement mortar, wire or expanded metal lathing, or of fire-brick, or in other cases left bare; while this construction tends to cut off the picker room from the remainder of the building, it is not as good a construction as the entire separation by means of brick fire walls.

DISCHARGE CLOSETS OR ROOMS FOR WASTE PICKERS.—Waste pickers should discharge into rooms lined with locked jointed tin.

OIL ROOM.—When detached from all other buildings, or when contiguous to, but separated from, all other buildings, should be of brick, with unfinished walls, tile, fire-brick or lock-jointed tin following, all angles of the wood, or of some other non-combustible material; the floor should be of cement with a pitch towards a drain which will carry any flowing oil away from the vicinity of all of the buildings.

Where the room is inside of a building, the construction should be the same with all openings protected by standard fire doors or shutters.

DRY-KILNS FOR LUMBER.—Should be detached from all other buildings, and should preferably be of brick.

MALT KILNS.—Should be of a construction similar to that of bone-black char houses at sugar refineries, but if the roof is of wood it must be of sufficient distance above the kiln to give good ventilating space, and should be provided with a good sized ventilator; the floors should be of perforated iron, and no wood should be in the construction other than what is in the roof.

BONE-BLACK CHAR HOUSES AT SUGAR REFINERIES.—Should be of brick with tile or fire-brick or brick arched roofs, cement floors and unfinished walls; all inside fittings should be of brick or iron.

OIL, LARD, AND ALL OTHER INFLAMMABLE MATERIALS, REFINERIES.—Should be as near fireproof as possible.

SMOKE HOUSES FOR MEATS.—Should be of brick, unfinished walls, floor at bottom of earth or cement or brick; first row of hangers should be of sufficient height above the fires to prevent fires setting the meat and hangers afire; roof should have a good metal ventilator.

PITS IN ELECTRIC CAR SHEDS, BARNS OR REPAIR SHOPS.—Should have earth, brick or cement floors, and only be under the tracks, and should not communicate with each other; side and end walls should be of brick built up solid to floor level of barn, etc.

STANDARD ELECTRIC LIGHT AND POWER STATION.—Brick or stone, either one story or one story and basement, in height, with a non-combustible roof, and a brick, stone or metal cornice; brick, stone or concrete floors; no wood (except in window frames and door frames) in the construction; boilers in separate rooms cut off from generator room by a fire wall; wire tower should be of brick or stone.

GRAIN ELEVATOR.—Either the machinery floor alone, or all of the "Texas," should be supported on good solid posts, independent of all bin work and running from the ground up;

boiler house must be in a separate brick or stone building with a fire wall on side towards the elevator, and stacks should be of brick, at least 20 feet from the elevator and at least 2 feet higher than peak of elevator roof.

PROSCENIUM WALLS IN THEATERS.—Should be of brick, at least 3 feet parapet, stone coped, with asbestos curtain on stage opening and standard fire doors on all other openings.

VARNISH AND OIL BOILING HOUSES.—Should be of brick, one story, with brick or concrete floor, non-combustible roof, and have a division wall between each two fire-places, and a brick stack with entire opening and hood directly over each fire-place; should be cut off from all other buildings by fire walls.

Varnish boiling rooms, oil boiling rooms, boiler rooms, where the ventilation is poor or boilers close to the overhead construction; hot rooms in print works, core oven and all similar rooms, in which there is a very high degree of heat used, or in which extra hazardous processes are carried on, should preferably be built brick arched, or with steel trusses thoroughly fireproofed with fire-bricks or tiles, supporting fire-brick or tiles roof construction; no wood should be used in their construction.

TANNERIES.—The bark mill should be located in a house cut off from the remainder of the plant by fire walls. If detached, all openings in any brick or stone buildings exposed to the bark mill should be protected with standard fire doors or shutters.

Enameling rooms should be cut off from the remainder of the plant by fire walls wherever possible.

All buildings should be whitewashed or painted regularly, especially should the bark mill and leach house be so treated frequently.

GRAIN DRYERS.—As this subject is so fully treated in the pamphlet on the Construction and Installation of Grain Dryers, issued by the National Board of Fire Underwriters, simplification for the understanding of the non-technical is unnecessary. It is reproduced here in full.

As the use of grain dryers in connection with elevators is becoming more general on account of the increasing demand for artificially dried grain for shipment, and as the machinery for drying grain has been perfected to such an extent that it is both effective and profitable to the user, the adoption of definite and uniform rules regarding their use is deemed necessary in order to obtain the greatest degree of safety in the arrangement and application of drying plants of this character.

Several kinds of dryers are now on the market, varying in detail, but all involving the use of certain features which may be enumerated as follows:

1. A receptacle containing the grain while drying, and which is traversed by air passages.
2. A system of steam coils or radiators to heat the air used for drying.
3. A blower or fan to force the air over the steam pipes, thence through the grain.
4. An air trunk or chamber confining the heated air after it leaves the coils and to direct and distribute it through the grain.
5. An exhaust space or conduit receiving the moisture-laden air from the grain and conducting it to the outer air.
6. Spouts or carriers of grain from the elevator to the dryer and from the dryer to the elevating buckets of the elevator.
7. Some form of enclosure containing the apparatus which may be independent of or form part of the apparatus.
8. Some form of power for operating the apparatus which may or may not be independent from the elevator.

HAZARDS.—The several elements of fire hazard attending the use of grain dryers are as follows:

1. The use of blowers, increasing the danger of fire in a greater or less degree, according to the speed at which they are driven.

The form of the air passages and the thickness of the grain layers determine the air pressures necessary to accomplish the desired results. The higher air pressures are accompanied by the higher fan speeds, increasing the probability of hot bearings with their attendant dangers.

Small air passages to the grain may produce high velocity of the hot air at these points, concentrating it in a jet upon any substance in its path and increasing the carbonizing effect.

2. The presence of a forced-air draught, causing the circula-

tion and accumulation of dirt and grain dust and increasing the danger of possible dust explosion.

The closed construction of most all dryers renders it difficult to extinguish a fire, and in case of explosion this construction insures the maximum of the destructive force.

The rapid spread of fan-driven fires, particularly in vertical shafts, makes it almost impossible to successfully contend with them.

3. The use of steam coils, usually under pressure of live steam.

The accumulation of dirt and the careless disposition of oily waste in the enclosure containing the coils have been the cause of fires in apparatus of this nature in the past.

4. The drying out and preparation of the surrounding woodwork for the rapid spread of fire, if the apparatus is inside of the building.

The constant movement of the building due to the loading and unloading renders it almost impossible to keep the apparatus tight and in perfect order if placed inside the building.

5. The use of a system of lighting, in the dryer, for the use of the operator.

6. The hazard attending the use of a steam engine or the motive power necessary to operate the apparatus.

DESIRABLE FEATURES.—The following features in the design and construction of grain dryers are desirable and tend to reduce the danger of fire to a minimum:

1. The dryer should be accessible and as open in construction as possible so as to afford access for the attendant and so that all portions may be reached by fire streams.

2. The layers of grain through which the hot air is forced should be as thin as practicable so as to permit the use of air under low pressure, and therefore a comparatively slow speed at the fan.

The area of grain through which the air passes should be as large as possible for the same reason.

Cases are on record where temporary wood parts of a grain dryer have been charred in one day by concentrated air jets of comparatively high velocity, and where the temperatures at the fan were less than 200 degrees Fahrenheit. It would appear from this that small air passages so arranged that the velocity of air is materially increased would have a tendency to overheat the grain and increase the fire hazard.

3. The dryer should be self-cleaning and free from all parts liable to fill with dust and dirt. Wire netting is more or less objectionable on account of its liability to clog with dust and chaff.

4. The air spaces should communicate freely with the outer air by window and ventilator openings so as to afford vent in case of explosion.

RULES AND REQUIREMENTS.—The hazards incident to the use of grain dryers can not be eliminated or safeguarded to such an extent that their introduction inside the elevator would not cause a material increase in the fire hazard. Their introduction inside the elevator is prohibited.

The following rules and requirements for the proper installation of grain dryers outside of elevators are applicable to both portable and stationary dryers.

THE BUILDING.—1. The shaft or enclosure containing the apparatus to be constructed entirely of brick and non-combustible material, and located at least 6 feet away from the elevator.

The distance of 6 feet between the elevator and the dryer building is sufficient for the elevating machinery, but a greater distance is advised in all cases where the yard room will permit. Enclosures containing dryers of doubtful safety and not fulfilling the requirements of this standard must also be located at a greater distance from the elevator.

A brick structure detached and without openings to expose the elevator is considered the best method of enclosing apparatus of this kind. The building could be more cheaply constructed of sheet iron on a steel frame work, but this rusts badly from the condensation of moisture given off by the grain, and is not proof against a hot fire. Sheet metal construction would necessitate the removal of the structure to a much greater distance from the elevator.

2. The roof should be of tile on steel supports, so constructed as to afford vent in case of explosion.

3. The openings in the side walls of the structure above the first floor to open away from the elevator. This is not meant to include the necessary openings for shaft, rope-drive or spouts.

4. The spouts between the elevator and dryer building to be of metal, on metal supports and provided with tight self-closing dampers so arranged as to remain closed except when the grain is passing through them.

5. The windows to be protected by wire netting.

6. The structure not to be lighted artificially except by incandescent electric lights or other approved method.

THE DRYER.—1. All parts of the apparatus to be constructed of metal or non-combustible material, including the garner, supports, spouts, etc. All parts to be smooth, so as to afford no chance for the lodgement of dust and dirt.

2. Elevating machinery for reconveying the grain to the elevator to be located outside the dryer building.

3. When the dryer is constructed to operate independently of the machinery in the elevator the enclosure containing the cables and elevating machinery operating the dryer must be entirely of non-combustible material and must not communicate with either the main building or the dryer building except by spout and cable openings.

4. The spout leading from the dryer to the machinery for reconveying the grain into storage to be provided with a cut-off slide so that the flow of grain from the dryer can be controlled.

5. The dryer to be provided with a spout for draining the grain into the lower or ground floor or with a receiving hopper of sufficient size to contain all the grain in the apparatus.

In case of fire the burning grain may be drawn into the hopper and smothered or into the ground floor where the fire can be more easily extinguished.

6. The blower or fan to be entirely of metal and provided with self-oiling bearings.

7. The blower and steam coils to be located within the walls of the dryer building.

8. The steam supply and power to be so arranged that they can be independently controlled from outside the dryer building.

9. No other heat except steam to be used.

SAFEGUARDS RECOMMENDED.—Notwithstanding the fact that the grain and foreign matter mixed therewith are the only materials of a combustible nature contained in a structure constructed in accordance with the above regulations, it is believed that a fan-driven fire in this dust and grain would result in considerable damage to the apparatus and possibly to the structure. For this reason the following recommendations for safeguards are appended:

1. An adequate system of automatic steam jets should be provided for extinguishing fire in the apparatus. High degree automatic sprinklers can be arranged so as to automatically fill the apparatus with steam in case of fire.

The steam pipes for sprinklers and all other parts of the apparatus should be so arranged that all condensation can be removed during cold weather and when the dryer is not in use.

2. If the fan is driven by an independent engine a system of fusible links should be so arranged that the fusing of any link would close a shut-off valve on the steam connection supplying the engine. Attachments for automatically stopping the fan when the power is from other sources should be provided if practicable.

3. An automatic fire alarm system should be installed, placing alarms in the engine room and at other points if desirable.

4. A thorough system of automatic sprinklers should be installed when the dryer is used in connection with a sprinklered elevator. When installed outside the elevator and in accordance with the above rules and requirements, grain dryers even of approved construction are considered as adding to the fire hazard of the elevators in connection with which they are used, according to the construction of the dryer building, and the distance which they are removed from the elevator.

STANDARD COTTON WAREHOUSE. — Sixteen-inch partition walls, 3-foot parapet and not less than 12 inches in thickness above the roof, and extending 3 feet beyond the front and rear faces of the warehouses; frame front and rear of clapboards, nailed to posts; floors of concrete or planking; roofs of standard, "slow-burning," "mill construction;" capacity should not exceed 600 bales of cotton standing on ends one bale high.

Where extra hazardous processes are carried on in any room where other processes are also carried on, the portion of the room occupied for the extra hazardous processes should be cut off from the remainder of the room by a partition of fireproof brick or tiles, wrought iron frame work, finished with wire netting and plaster, or expanded metal laths and plaster, or wired glass in proper frames. The floors should be of fireproof brick or tiles or cement.

NOTES.—Any hollow space, whether in cornice, wall, floor, partition or any other part of the constructional part of a building, presents an increased hazard, as it forms a possible lodgment place for inflammable and spontaneously combustible materials, is a concealed space in which a fire may develop to a very great extent before it is discovered, and is usually a draft hole which would contribute to the rapid and non-preventable spread of a fire; hence it is of the greatest importance that these hollow spaces should be obviated in construction, done away with wherever found, or so divided up by fireproof partitions as to make the concealed space of as limited an area as possible.

All holes in floors, whether cracks, worn places, spaces around columns, loosely fitting flooring, either between the floor boards or at the walls, should be repaired so that the flooring is tight; this is especially necessary in "hollow construction," as here the liability of papers, matches, lighted cigars and cigarettes, inflammable and spontaneously combustible rubbish and materials falling through the openings in the floors into the concealed spaces below is a very decided and greatly increased hazard.

CLOSETS.—These constitute concealed spaces, and, therefore, attention should be given to their construction. Wooden tops are not desirable; a top of paper will keep out the dust and should be used instead of wood; the doors should be provided with glass, so that the interior of the closet is always in view Closets for workingmen's clothes should have wire-netted doors.

PARTITIONS.—Wooden studding, lath and plaster, or wood ceiled partitions simply add more concealed spaces in a building, and are very objectionable and should be removed wherever possible. Two-inch tongue and groove or splined planking, well set up, makes a good solid partition and presents a surface which offers resistance to fire. Fireproof bricks and tiles make the most desirable partitions. If a wooden studding is to be built it should be wire-netted or provided with expanded wire laths and the plaster put on the netting or metal laths.

Where openings in walls or partitions for light are necessary, and where without these openings the walls would be fire walls or the partitions would be solid, wired glass can be used to great advantage. The minimum thickness for the glass is one-quarter-inch (full) if rough plate, ribbed or figured, and no polished glass less than 5-16 inch can be used (this 5-16 inch to be the thickness after the glass is polished); the maximum mesh of the wire is 1 inch, and it must not be smaller than No. 22 B. & S. wire gauge. This glass must be set in suitable frames, hollow metallic or wrought iron, and no vent spaces must be left around the frames of the glass. Prism glass, in which the glass units do not exceed 4 inches in either direction, and are of a minimum thickness of 3-16 inch, when set in proper frames can be used in special cases.

SHAFT OPENINGS IN FIRE WALLS.—Should be protected by fire-doors made of two thicknesses of ⅞-inch narrow, matched, thoroughly seasoned boards, put together at right angles and securely nailed with wrought iron clinch nails and covered with heavy tin plates, locked joints, nailed under the seams, as per specifications for standard tin clad fire doors, and be hinged to a single stud bolt in wall, and retained at bottom by proper reverse angle, securely bolted to the wall. (National Board of Fire Underwriters.)

BELT OPENINGS THROUGH WALLS.—Should be protected by double fire doors or metal hood.

Double doors should be made of the same thickness and in the same manner as standard tin clad fire doors, and arranged so as to slide in upper and lower guard rails or channels, which shall retain them in place; these channels to be made of 2¼x2¼x¼-inch angle irons securely riveted together and secured by ¾-inch bolts through the walls. Z bars of proper dimensions may be used if obtainable. Channels to be long enough to retain doors when open. Doors to be provided with suitable hooks and staples for holding them closed.

Metal hood made of heavy galvanized iron, in such a form as to completely cover the belt, and the pulley over which it runs should be securely fastened to the wall around the belt hole. No solder must be used in the construction. Metal hoods are inferior to double doors and should be used only when the doors are not practicable. (National Board of Fire Underwriters.)

WIRED GLASS for SKYLIGHTS is strongly advised.

Where openings are not seriously exposed wired glass set in suitable frames or wired glass shutters can be used in place of fire shutters. For the purpose of retarding the spread of fire wired glass is more efficient than prism glass.

BRIDGE TRUSSES.—Where long bridge trusses are used to support roofs the walls on which the trusses rest should be carefully inspected as to their strength, and where they are seemingly inadequate for the weight carried, with an additional weight of outside foreign material (as burning timbers, etc., in case of fire in exposures), the trusses should be supported by independent posts running from the ground up.

PAINTING SHEET METALS.—Exposed sheet metal (metal roofs, sides, etc.) should always be painted. Iron oxide paints are the best for metal as they adhere more firmly than lead paints.

Wherever possible iron posts should be protected against heat by covering them with fireproof brick or tiles, or wire netting, or expanded metal laths, the netting and laths being covered with plaster.

The bright tin of fire shutters and doors should be given a coat of asphaltum before being painted, and the paint put on should preferably be of a light color.

FIRE-RETARDING PAINTS.—Whitewash made of lime and water with a quantity of salt added is the best fire retardant of this character. Frequent coating is necessary, as the dried whitewash flakes and peels off. Cement-wash, made of hydraulic cement and water, is a very good wash and more lasting than whitewash. The various paints known as "fireproof," are more or less fire retardants, but must be carefully applied; where placed upon non-porous materials they are apt to lose their effectiveness by peeling off. Oxide of iron paints are the best for metals.

FIRE-RETARDING COATINGS.—Thin board partitions and uneven surfaces can best be treated by covering them with sheet asbestos, and placing over this a covering of lock-jointed tin. There are various other materials, such as air-cell fireboard, plaster board, plastered wire netting, but all must be properly laid on to be effective, the primary point being the exclusion of air between the covered wood and the covering.

Fireproofed wood is not as yet a commercial commodity, and has not yet reached a point where it can be generally used in an economical way.

Oil, shellac and varnish finish are not recommended on account of the increase of inflammable material in the building.

The height of a building, under public fire protection, should be governed by the height to which the fire department can throw a good 1⅛-inch fire stream, as buildings in excess of this height would lack proper protection in case of fire.

MORTARS—CEMENT MORTAR.—A mortar in the proportion of three parts of sand to one of cement, when applied immediately upon mixing, makes a strong and binding mortar. Lime mortar should be made of four parts of sand to one of lime, and should not be used until thoroughly slaked. Cement and lime mortar should be one part of cement, one part of lime and three parts of sand. All of these proportions can be varied for different classes of work, but are good bases for mixtures.

Wooden laths should be removed wherever possible, as should all furring and wooden sheathing.

There should be as few openings as possible in any walls. The basis for area rate, universal schedule, is 2,500 square feet.

CHAPTER III.

FIRE DOORS AND SHUTTERS.

There are a great many "so-called" fire doors and shutters, often on very important openings, which, when exposed to only a relatively low degree of heat, would prove to be entirely worthless. They may be of iron, whether heavy or light, which will warp and bend and practically uncover the opening, when exposed to heat, or be of wood covered with iron (corrugated, galvanized, etc.), which will buckle and bend and pull the nails out and thus leave the wood exposed, or be improperly covered with tin. Hangings are apt to be of poor quality and improperly placed, and fastenings are not of proper strength or construction, and in numerous other particulars the doors and shutters are weak and practically worthless.

There is only one kind of fire door and shutters that is of such a character as to be of real value and dependence, and that is the standard tin clad.

STANDARD TIN CLAD FIRE DOORS (National Board of Fire Underwriters).—The woodwork should be of sound, well seasoned white pine or similar non-resinous wood, dressed, tongued and grooved boards, not over 6 inches in width, and when there is a door on one side only of an opening the thickness of the wood should be at least 2½ inches; where the wood is 2 inches thick there should be two layers of 1-inch boards, one laid vertically and the other diagonally or at right angles; where the wood is 2½ inches thick there should be three equal thicknesses of boards, the outside layers being vertical and the inner layer horizontal. The layers to be securely fastened together by wrought iron clinch nails, driven in flush and clinched, so as to leave smooth surfaces on both sides of the door.

Tin Covering.—Tin plate to be 14x20 inches, "IC" charcoal, 108 pounds to the box. The corners should be covered first, a whole sheet of tin being used without cutting, making a mitre fold with it. The edges should next be covered, the tin being locked into the corner plates without nails. The sides should then be covered, one at a time, the tin plates being put on with locked joints. All locked joints to be ½ inch, and nailed under the seams with 1½-inch long barbed nails for 2½-inch doors, and 1¼-inch barbed nails for 2-inch doors. No solder to be used. Use "terne" plate where doors are exposed to dampness.

Hardware for Sliding Doors.—The track to be of best quality flat rolled steel, ⅜-inch thick by 3½ inches wide and bolted every 2½ feet with ¾-inch bolts running through the wall, having nut and flanged washer on the opposite side. The hangers to be of wrought metal, ⅜x3½ inches, and attached by ½-inch bolts. Wheel to have not less than 1½-inch bearing on axle, roller bearing preferred, and to be of malleable or wrought iron; the long end of hanger to be not less than 18 inches, and to be drilled for not less than two ½-inch carriage bolts. For doors less than 6 feet wide two hangers are sufficient; for doors over 6 feet wide three hangers to be used. Wrought iron binders ⅜x3½ inches, drilled for ¾-inch bolts; each binder to have an angle flange at back end, 1 inch deep to notch in wall, or to have two bolts, to prevent sagging; two binders are required, one at side near floor and one at same side near top, into both of which the door closes. A roller guide to be located near bottom of door at opposite side from binder stops; guide to be of wrought metal, ½x2 inches, the base to be "U" shape, countersunk in floor and wall and bolted to wall; a flat piece of metal to be attached to front of door to take wear of roller guide. Chafing strips of 1-inch half-round iron to be screwed to door on side next wall, located one-third the distance from bottom to top of door, parallel to door track, ends to be 6 inches from side of door. Two handles required on each door; one large, heavy, wrought iron, bow-shaped handle to be bolted to front of door, and one handle to be countersunk flush with surface of door. Two bumper shoes placed on the door where it strikes the binders in closing, to be of 1-16-inch plate iron. Hard plaited cord with a 160-degree fusible link, so placed in its length as to be in the open doorway when the door is open, to hold the door open by a weight on the end not attached to the door.

Hardware for Swinging Doors.—Wall eyes of wrought iron, for ¾-inch pin, built in wall or bolted through wall with ¾-inch bolt, with 3-16-inch iron washer each side; bolts should always be put through brick work far enough from edge of opening to prevent weight of door loosening the masonry. The hinges should be of wrought iron, ⅜ x 2½ inches, bolted to door with four ⅜-inch bolts; hinges to extend three-quarters way across door. The latch to be of wrought iron, ⅜ x 2 inches, bolted to door with ⅜-inch bolts; keeper to be wrought iron, and also bolted to door. Catch to be of heavy wrought iron built in the wall or bolted through it.

All wrought iron sheaves, hinges and latches to be secured by bolts passing through door, the head of bolt resting against a washer next to the tin, the nuts being against the wrought iron. Do not use screws to attach any hardware except chafing strips, bumpers and automatic attachment. Do not use builders' ordinary cast iron hardware, and use only the best quality of bolts.

Sills should be of stone, built into wall at least 6 inches at each end, and extended under and flush with outer surface of door, or of wrought iron or steel plate not less than ¼ inch in thickness, on brick, stone or concrete support, built into wall at least 6 inches at each end and extended under and flush with outer surface of door, or of concrete placed between suitable angle-irons and made flush with their upper surfaces. This angle-iron to be placed on each side of the wall, to be not less than ⅛ inch in thickness, to have faces of equal width, to extend 6 inches beyond the opening at each end, to be held in place by ¾-inch bolts run through the wall and to have its horizontal face extend under and its edge flush with the outer surface of the door.

The lintel should preferably be a brick arch.

Sliding doors must overlap sides and top of opening 4 inches.

Swinging doors to shut into a brick rabbet in wall or into a 2½ x 2½ x ¼-inch iron rabbet secured on each side with ¾-inch bolts through the wall, or into an approved door frame having jambs of rabbetted 2½-inch angle-iron ¼ inch thick, and held firmly in place by at least three ¾-inch bolts each side, passing through wall, with metal sill well secured to the iron frame and catches for latches, also pin blocks to receive the hinges, of heavy wrought iron and properly riveted to the iron frames.

Vertical sliding doors can be used where swinging or horizontally sliding doors cannot be used. Malleable or wrought iron wheels should be used, and the cord connecting with the fusible link should be attached to lower part of door, passing over its proper pulley to the left and supporting the smaller weight. The heavier weight is permanently connected by a wire cable to the upper loop at top of door, and is adjusted to prevent the sudden dropping of the door, but allowing it to close when link fuses.

STANDARD TIN-CLAD FIRE SHUTTERS (National Board of Fire Underwriters).—The construction is the same as that of standard tin-clad fire doors, excepting that only two thicknesses of ⅞-inch boards are required. When the shutters are made in pairs the edges coming together should be flush and not rabbeted. Hinges to be of wrought iron 5-16 x 1¾ inch, secured by bolts passing through the shutter, with washers under the bolt heads. The pin, or eye blocks, to be of substantial wrought iron, set in the wall or bolted through the wall. The shutters must be hung next to masonry, either overlapping window openings 4 inches or fitting close to the inside openings, and must be securely shut by an iron bar ⅜ x 1½ inches bolted through the shutter, and at least one shutter in three on each floor above the first to be constructed so that it can be operated from both the inside and the outside; catches must be bolted to the shutter.

STANDARD IRON DOORS, VAULT PATTERN (National Board of Fire Underwriters).—The sills must be of iron or steel and raised not less than 2 inches above the floor on each side of the wall; if they are of plate iron or steel the edges must be securely fastened to 1½ x 1½ x ¼-inch angle-iron, or heavier, on the inner side of the wall frame; in all cases they must rest substantially on the solid brick wall and extend to the upper edge of the wall frame. The basement floor must be of stone or concrete where the doors are to swing; in no case to be of wood unless the door swings clear of wood at least 6 inches. The wall frame must be of 4 x 3 x ⅜-inch angle-iron, or of 4 x ⅜-inch bar iron stiffened by 1½ x 1½ x ¼-inch angle-iron riveted on the back; the bottom pieces of frame to project 2 inches above floor, and each set of wall frames to be connected by bars of 1¼ x ¼-inch iron, spaced not over 24 inches apart all around, except where sill acts in place of bars, or by ⅝-inch bolts through the wall and spaced not over 24 inches apart, and the top and bottom pieces of wall frame to be joined to side pieces by wide splice plates of ⅜-inch iron securely riveted in place. Door plates must be securely riveted to the panel frames and panel bars, and must be of 3-16-inch iron or steel thoroughly straightened, and must overlap wall frame at least 1 inch on all sides, or if doors are flush, to shut into at least ⅝-inch rabbet all around, formed by angle on back of wall frame. Panel frame must be made of 2 x 2 x ⅜-inch angle-iron, continuous with bent corners or with corners reinforced by fillet angles where joined, the fillet angles being securely riveted in place; the frame to be stiffened with 2 x 2 x ⅜-inch angle-iron panel bars, with ends offset so as to extend over sides of frames, or ends may be fastened with fillet angles, each frame to be provided with at least two panel bars, and where doors exceed 7 feet in height panel bars not to exceed 2 feet part.

Fittings.—At least three wrought iron hinges must be used, those riveted to the wall frame to be at least 4 x 3 inches and made of ⅜-inch iron or heavier, and to be fastened by three ⅜-inch rivets; the hinges on the doors must be constructed of 2 x ⅜-inch bar iron bent to overlap the panel frame on the hinge side; upper and lower hinges to extend across the door to panel frame on opposite side; center hinge to extend at least one-half of the distance across the door; must be securely riveted to door plate and through panel frame on each side, pins being of ⅝-inch turned steel.

Doors to be secured by at least three lever bars of 1½ x ⅜-inch iron, working together, upper and lower lever bars not to exceed 12 inches from upper and lower edges of door opening, and must be secured both in front and back by at least two lugs or binders on each side, made of ⅞-inch round iron passing through holes in the angle-iron panel frame when the door is closed; lugs to be so arranged that they will bind door to the wall frame when it is closed and latched, and to be securely riveted or bolted to the wall frame and in back of wall frame.

Rivets to be of Norway iron, at least ⅜ of an inch in diameter and spaced not over 6 inches apart.

Steel rivets should not be used.

DOUBLE SWINGING DOORS IN PAIRS.—To have two opposite doors fastened together by hooks of ⅝-inch round iron, bolts or spring catches at top and bottom, and the right-hand door to fold over left-hand door, lapping at least 1 inch, or, where the doors are flush, to fold into rabbet at least ⅝ inch; catches to be of ½-inch Norway iron securely riveted through door plate and angle-iron panel frames.

SLIDING DOORS, NOT AUTOMATIC, to slide in channels at the top and bottom, the latter channels to be formed by two angle bars 2½ x ⅜ and 1½ x ¼ inches, the top channel to be formed by two angle bars 2 x ⅜ and 1½ x ¼ inches; they must be securely riveted or bolted to the wall frame, and where they extend beyond the wall frame, to be firmly bolted to the wall by expansion bolts (½ x 4½ inches); the lower channel to extend beyond the wall frame at least 12 inches on the side toward which the door opens. The doors must be secured both in front and back by at least two lugs or binders on each side, made of ⅞-inch round iron passing through holes in the angle-iron panel frame when the door is closed, the lugs to be so arranged that they will bind door to the wall frame when it is closed and latched, and must be securely riveted or bolted to the wall frame and in such manner as to prevent turning. The hangers to be of the anti-friction pattern and securely fastened to the door plate by at least four ½-inch machine bolts at each fastening, at least two hangers to be placed on each door; the wheels must be of cast iron ¾ x 4½ inches, and may be constructed with curved grooves so as to bear only on each edge of the ½-inch track, which latter must be without incline, of ½ x ½-inch iron securely riveted on the upper side of the angle-iron channel, and to be perfectly true and without obstruction to wheels.

The door must be provided with a latch formed of 2 x ⅜-inch iron, to which the handle is fastened.

AUTOMATIC SLIDING DOORS.—The cord on the latch side to be of flexible phosphor bronze, securely attached to the door; the remainder of the cord may be of the usual form; the link must be so placed as always to be in door opening, and so arranged that when it gives way under heat a sufficient excess in weight will be exerted to pull and latch the door closed. The cord sheaves must be securely fastened to the wall with expansion bolts, and must be provided with bronze bearings, and so constructed that the cord cannot jump the grooves. The latch must be provided with a suitable coiled spring to hold it in place and to insure fastening.

Automatic swinging doors require a different arrangement of the link and weights closing the doors. Weights to be properly boxed and placed between doors. Cords to pass through holes drilled in wall frame and to be so arranged in sheaves that the fusing of the link will release sufficient weight to pull and latch the door closed. Fusible links to be placed near the ceiling and arranged so that the fusing of the link on either side of the wall will operate both doors; several links may be placed on either side if desired. The cords closing doors should be sufficiently weighted to keep them taut when the doors are opened and closed. When these doors are in pairs they must be so arranged that the right-hand doors will fold over the left-hand doors. This requires an automatic stop or trigger at the top of the doors, which will hold the right-hand sufficiently open to allow the left-hand door to close first. The closing of the left-hand door releases the trigger and allows the remaining door to close. The left-hand door to be provided with spring bolts or latches at both top and bottom, these to be operated from either side of the door by proper handles at the centre.

STANDARD SHEET IRON DOORS (National Board of Fire Underwriters).—These doors are lighter than the vault doors and differ from them in the following particulars. No. 12 guage sheet iron or steel is used instead of 3-16-inch plate, panel frames and bars are made of 2 x 2 x ¼-inch angle iron instead of 2 x 2 x ⅜-inch.

Standard sheet iron doors may be used in less closely built up districts and in localities where exposure is not liable to b- severe. They are not recommended.

STANDARD IRON SHUTTERS (National Board of Fi Underwriters).—Must be made of sheet iron or steel, No. 14 gauge and lap the wall at least 1½ inches all around; if not practical to lap at the bottom must fit the sill closely. Frames to be of 1½ x ¼-inch angle iron, with not less than two cross bars of the same material, and to enter wall opening when shutter is closed. Shutters over six feet in height to have cross bars not exceeding two feet apart. To have not less than two lever bars, extending at least one-third of the distance across the opposite shutter, when double shutters are used, of 1½ x ⅜-inch iron, and where over six feet in height lever bars not to exceed two feet apart; these bars to work together by ⅝-inch connecting rod and fastened into substantial lugs, riveted on each shutter or to proper fastenings in the brick wall if the shutters are single. Hinges to be of 2¼-inch iron, extending at least three-fourths of the way across the shutter, and not to exceed two feet apart when the shutter is over six feet in height. Pin blocks or shutter eyes of ½-inch round iron, to be securely set in brick walls, preferably while building. On finished buildings pin blocks or eyes should be firmly set in holes drilled in brick and fastened with iron wedges and cement. Rivets to be of iron at least 5-16 inch in diameter, and placed not exceeding six inches apart. Hooks or gravity catches in wall to be provided to hold shutter in position when open. At least one shutter in three on each floor above the first to be constructed so that it can be operated from the inside and outside, the handles on the outside to be so constructed that they can be operated by hand or pike pole. Shutters to be thoroughly painted with two coats of iron oxide and boiled oil or equivalent.

STEEL ROLL FIRE DOOR AND SHUTTER (National Board of Fire Underwriters).—Should not be used where standard fire doors and shutters can be employed; otherwise for front or rear openings, exposed across narrow streets or alleys, they are recommended if of approved construction.

NOTES.—All materials used to be carefully and thoroughly straightened before the door is put together. Scrap or short pieces not to be used where such material should be avoided. Rivets to be drawn tight. Doors to be made, finished and hung n a thoroughly workmanlike manner. Strips to be screwed to loor and heads of screws must be countersunk.

Arrangement and Setting Up.—The thickness of the wall should be accurately measured, so that the bars or bolts fastening wall frame together can be cut to the exact length. If the door is not installed when the wall is erected, or is not placed in an old opening, the opening should be cut larger than the frame and the jambs built up to the proper size, using cement mortar and thoroughly pointing up around frames. Frames to be set perfectly level and plumb and doors hung so as to fit the wall frame closely all around. All doors to swing or slide freely and without binding, care being taken to see that the latches or lever bars fasten properly.

Use tin plate 14 x 20 inches, "IC" charcoal, 108 pounds to the box.

When necessary a light frame work of slats should be built outside of sliding doors to prevent piling of stock, etc., against them.

Bright tin doors resist fire better than if painted.

Do not paint the doors unless it is necessary, and do not until they have first been given a coat of asphaltum. A light-colored paint does not absorb heat so readily as dark-colored paint.

It is well to paint all iron parts of doors with iron oxide mixed with boiled oil.

Fire doors and shutters should be ready for instant use at times, therefore it is necessary to keep the surroundings clear of everything that would be likely to obstruct or interfere with their free operation.

Fire doors and shutters should be kept closed and fastened at nights and on Sundays and holidays, and whenever the openings are not in use.

Never tack any tin on a tin-clad door or shutter.

When tin becomes worn substitute new sheets in the same manner as when covering a new door.

Sheet iron, galvanized iron and other thin sheet metals, excepting proper sheet tin, are of practically no value as coverings for fire doors, as they do not adequately withstand heat, rust away, cannot be properly put on the woodwork, and buckle and bend with comparatively little heat.

Metal-clad doors, with the sheet metal nailed on in such a manner as to expose the nail heads, are of but little value as fire doors, as the heat will cause the nail to char the surrounding wood and the spring of the sheet metal will then force the nail out and drop the metal from the wood.

Sheet metal put on woodwork otherwise than lock jointed will not prove of much value, as the heat will soon reach the wood between the sheets.

Soldered joints must not be used, as the solder will melt and the joints come apart.

The fire resisting value of a wood door encased in tin depends upon the exclusion of oxygen from the wood, thereby retarding or preventing combustion. To obtain this result the tin must be so applied that during exposure to fire the tin will not leave the door nor will any joints or seams buckle open by expansion so as to expose the wood.

No exposed wood should be anywhere in the fire door, shutter, door frame or door sill.

CHAPTER IV.

HEATING.

Heating appliances are of such diverse characters, constructions and uses, that no general ruling can be given as to their construction, location or arrangement; that they should not be hazardously close to inflammable material is, of course, a necessary requirement, hence a free ventilating air space should be provided about them, and they should not be shut up in close, contracted locations, and all woodwork exposed to the heat should be adequately protected.

All woodwork directly exposed to any boiler, steam dome of boiler, breeching or flue should be covered with sheet asbestos overlaid with tin (standard clad), both closely following all lines and angles of the woodwork. A metal shield with air spaces on both sides affords some protection, but is not generally efficient for the purpose of protecting the wood from the action of the heat.

It is best from a point of economy, as well as a safe-guard from fire, to set all boilers and other heat-producing appliances allowing of same, in brickwork and covering them with some non-heat-conveying material. The loss of heat means the loss of just so much fuel to produce it, hence all heat wasted is fuel wasted, and in the operation of manufacturing plants this is a very decided item for the practicing of economy; the covering of steam pipes with the various coverings for retaining heat is a point in which one economy of operation in a manufacturing plant is exhibited, therefore the covering of all heat-producing appliances to reduce heat radiation where the heat is not needed acts as much in the interest of economy as in the reduction of the fire hazard, but it is not well to cover a pipe to a floor or partition, let it run through these bare, and then cover it on the other side of the floor or partition, for then an excess of heat is retained at the worst possible point, the covering of heat-conveying pipes where they pass through wood or any other inflammable material with some non-heat conveying material is to be desired under any and all conditions.

Bake oven, pyrites and sulphur burners, furnaces, etc., for annealing, coffee roasting, super-heating steam, class melting, concentrating, smelting, metal melting in hat factories, etc.; glory-holes, heaters in rolling mills, core ovens, converters, etc., should be, preferably, all of brick, although iron may enter into their construction; should be on earth, brick, concrete or cement floors; must not be in contact with any wood, but must have clear air spaces at sides and tops, and should not be in contact with division or party walls.

Blow Torches and Furnaces—(National Board of Fire Underwriters): Kerosene Oil Pressure Systems.—The burner must properly generate under any condition of working pressure or regulation. All parts must be accessible for purposes of cleaning or repairs. Cleaning or needle valves must have steel stems with a shoulder which will act as a stop and prevent the enlarging of the gas tip. Furnaces must be provided with a shut-off valve between the tank and the burner, closing against the pressure in a positive manner. Connections with sheet metal must be made so that no joints will be entirely dependent upon solder.

Boilers (see also Chapter 11).—Set all boilers on or above brick, earth, cement or concrete floors. No high-pressure boiler, dome, breeching or flue of same should be within 10 feet of wood, and no pipe from low pressure boilers or heat appliances of low heating temperature should be within 2 feet of wood; if wood is within these distances it should be covered with some fire retardant. (See Chapter 11.)

Cooking ovens and ranges in restaurants, hotels, etc., should be on ventilated brick floors 10 feet from surrounding woodwork, 6 inches from brick or stone division or party walls, and should have hanging metal hood or brick arches opening into metal or brick flues, above and covering entire tops of the ovens; the hoods or arches are for the purpose of carrying off the inflammable fumes from the cooking. Wooden floors in front extending out for a distance of 3 feet should be closely covered with metal sheeting.

Coopers', or barrel stoves, should be on brick, concrete or cement floors, and not within 10 feet of any wood at sides or above, and should stand under brick or iron hoods and preferably be enclosed on three sides by brick or iron shields.

Char houses of sugar refineries should be entirely of brick and iron. These are heated by self-contained furnaces.

Saw mill refuse burners must be higher than peak of saw mill roof, and must be provided with a spark arrester on top, and be 50 feet from buildings and 100 feet from lumber.

Saw mill slab pit should be at least 100 feet from buildings or lumber in the direction from which the least wind blows, and placed at the bottom of any embankment on which buildings or lumber are located, or surrounded by brick walls on the three sides nearest to the buildings and lumber.

Cupolas.—Iron charging platforms should be used in preference to wooden ones; roof and wooden platforms should be at least 12 inches from the cupola, this space being filled in with a metal collar.

Bleaching with Sulphur.—Where sulphur is burned for bleaching it must be in an iron pot on iron legs or bricks; sides of pot should be at least 3 inches higher than pot of burning sulphur.

Doubling in distilleries must be done by steam only.

Phosphate dryers; no wood must be within 10 feet.

Licorice kettles in tobacco risks should be steam heated.

Dry Rooms.—These rooms are made for such varied purposes that it is only in a general way that they can be treated.

Where steam heat is used the pipes should be installed in accordance with the treatment indicated under heading of "Steam Pipes" (this chapter).

Where heated by coal-burning stoves the stoves should be as far from all surrounding woodwork as possible, and otherwise as per heading "Stoves Burning Coal" (this chapter).

Where heating by hot air is carried on, the steam pipes and blower should be located in a readily accessible place, and the material surrounding the steam pipes should be brick or metal, but not metal on wood.

Where heating is by direct heat from boilers, the floors directly over the boilers should preferably be of iron bars or wire netting; if of wood, the floor should be slatted, and there should be at least 10 feet open space between the boilers and the floor.

Where materials are dried by heat from steam pipes under wire netting, space should be left under the steam pipes for cleaning out any materials which may fall through the netting onto the pipes or floor.

Floors of dry rooms should be preferably of cement, bricks laid in cement, or concrete.

Vulcanizing and japaning rooms should be metal lined and steam heated.

Varnished woods, leather, etc., should be dried in open rooms with steam-pipe heat; stoves should not be used.

Hair should be dried on wire netting by cold air, hot air or by steam pipes underneath the netting.

Electric heaters should be placed similarly to gas stoves.

Forges (brick or iron) should have brick or iron hoods, and should be on earth, cinders, brick or metal-clad floors; if on the latter the sheet metal must closely cover the floor and extend 3 feet beyond the forge in each unprotected direction; brickwork must be kept in good state of repair.

Furnaces, boilers, etc., should be on earth, brick, concrete or cement floors.

Glue should be steam heated wherever possible; properly arranged gas stoves are good appliances, but oil stoves placed on insecure boxes or shelves are dangerous; if oil stoves are used they should be properly placed. (See Stoves Burning Oil, etc., this chapter.)

Hot Air.—The system of forcing hot air through a building by blowers is one of the safest modes of heating. The blower should be located in a separate room and the steam pipes be set in a metal or brick closet. The flues for carrying the hot air should preferably be brick; metal pipes should be kept clear of all inflammable materials, and all lint, dust, rubbish and other inflammable materials should be carefully kept brushed off of them. The hot air flues must be of adequate size to carry the hot air without any undue high velocity, caused by large volume of air being forced through two small flues.

KILNS.—In malt houses, pottery works, saw mills, etc., should be detached from all other buildings by open spaces or fire walls.

Malt houses and pottery kilns have self-contained brick or brick and iron furnaces on earth or brick floors.

Furnace heated lumber kilns are highly dangerous and should be done away with.

Lumber kilns should be hot air or steam-pipe heated.

Kettles and Stills.—All kettles for confectionery, varnish, butterine, paper, cloth, lard, stearine, brewery, oil, etc., risks should be as far as possible steam jacketed, or heated by inside steam coils, and should rest on iron standards, and be free from contact with any wood. Where heated on stoves they should tightly fit the stoves' openings. Where fire-heated other than directly on stoves the furnace must be of brick built on earth or bricks. There must be a brick hood opening full into a brick stack over each varnish boiling kettle.

Singeing.—Where furnaces are used (plate singeing) the furnaces should be set in a brick room or closet with a brick, concrete or cement floor; no wood should be within five feet of sides or top of room or closet. Where gas or oil is used the singeing machine must stand free of all surrounding wood at sides or above. Naphtha and gasolene should not be used for singeing unless absolutely necessary. Where singeing is done by hand all nearby woodwork should be metal clad.

Soldering Furnaces.—Where charcoal is the fuel furnaces must stand on large pieces of sheet metal. Where gas or gasolene is burned burners must have an open air space between them and any wood.

Steam pipes, when in contact with wood, are very liable to set the wood on fire by first carbonizing it and then by friction (caused by expanding and contracting pipes, and the vibration of the building), or by a slightly higher temperature, or by a chemical action due to the alternating cold and warm conditions causing the wood to enter an active state of combustion. It is, therefore, necessary to give particular attention to the location and arrangement of these pipes, whether high or low pressure of steam is used.

Keep them clear of all combustible materials, free from lint. dust, rubbish; do not allow stock to be put against them. If it is a rule to pile stock so that it is apt to come in contact with them, place a slat-work shield in front of them to prevent this.

Hang them all on well-secured iron brackets or overhead on iron holders, or (as in dry rooms, core boxes, etc.) where in lower part rest them on ½-inch to 1-inch iron pipe, preferably raised from floors on iron standards. For general heating the hanging of the pipes overhead is to be desired.

Where passing through wood or lath and plaster, partitions should be surrounded by double holed sleeves, or by sleeves of iron pipe at least ¾-inch larger in diameter than the steam pipe, and supported at each end by an iron collar, so arranged as to keep the pipe from contact with the sleeve pipe, or the space between the steam pipe and sleeve pipe must be filled with mineral wood.or asbestos. Where liable to come in contact with wood the wood should be covered with asbestos. Sheet metal between and against steam pipes and wood affords but little protection to the wood, as the sheet metal becomes as hot as the pipes.

Pans, digesters, evaporators, etc., must be clear of all wood and other combustible materials.

Smoke houses at packing houses should be of brick, without any woodwork other than that of roof construction. First row of hangers should be 12 feet above fires. A wire netting or perforated iron floor should preferably be placed between the fires and first row of hangers.

Stoves burning coal should stand on bricks, or sand in a box, or on a non-burnable floor cover or a metal floor cover, but not on sheet metal laid on a wooden floor, an unprotected wooden floor or carpeted floor. There should be a ventilating space between the bottom of the stove and the floor, bricks, etc. The bricks or floor protecting cover should extend under and two feet beyond the front of the feed door and ash door. Where stoves are near inflammable materials at sides metal shields should be used.

Stoves burning wood should have flooring underneath, protected the same as coal-burning stoves, and surrounding exposed inflammable materials should have same shield protection as coal-burning stoves, and should stand a good distance from inflammable materials wherever possible, as the heat in these stoves becomes excessive at frequent intervals, i. e., directly after the feeding of fuel.

Stoves burning gas should stand on metal (with an air space between the metal and any wood), on brick, stone, cement or concrete. Must never be placed on any unstable box, bench or other stand.

Stoves Burning Oil—Kerosene Oil Pressure Systems—(National Board of Fire Underwriters).—Stoves, water heaters or open burners must be supported on a substantial frame or stand relieving the piping from all unnecessary strain. Proper protection must be provided to prevent overheating or ignition of adjacent materials. Enclosed stoves must be provided with a suitable chimney connection. Must have a readily accessible shut-off and regulating valve. Must be provided with a metal pan, made tight without solder, and placed beneath the burner. Must be marked with the name of the stove and of its manufacturer.

Stoves burning oils and other burning fluids should be placed the same as gas stoves and, where possible, should have a metal pan under them of a capacity in excess of the oil reservoir of the stove, but stoves should not stand low enough in these pans to cut off air drafts under them. Oil stoves are not recommended for use, and should be discarded wherever possible.

Sulphur furnaces at acid works to be of brick, at least 5 feet from wooden sides of woodwork of any kind of the acid chamber, and, if of iron, to have a solid brick wall of not less than two-brick thick intervening; wall to rise not less than 3 feet above top of furnace. Floors of furnace room to be of earth, brick or stone. Roof of furnace room to be of non-combustible material, and at least 15 feet above top of furnace. (S. E. T. A.)

Sulphur-burning rooms of sulphite pulp mills should be entirely of brick, but where there is any wood in the construction it must not be in such proximity to the burning sulphur as to render it liable to ignition.

NOTES.—All heating appliances passing through floors or roofs (such as cupolas, glass furnaces, etc.) must have a space around them clear of any wood, where passing through same, of at least 10 inches. This space can be covered by a metal hood or heavy iron, not in absolute contact with the heating appliance.

Flues, gas conveyors, etc., to be treated the same as boiler breechings, etc.

Hot air or gas pipes (as in acid works, from burners, etc.,) to be treated the same as steam pipes or smoke pipes.

Heating devices on machines (as on stitching machines in boot and shoe factories) should use only steam, gas by an improved system, or kerosene oil in metal lamps. Steam for heating to have the preference.

Gasolene, naphtha and benzine-heated appliances should be discarded.

Woodwork directly exposed to any heating appliance should be closely covered with asbestos, overlaid with sheet tin (locked joints), following all lines and angles of the wood. Where the woodwork is not directly exposed to any heating appliance but apt to be overheated by it, should be protected by a metal shield having a clear air space on each side of it.

Special care and attention should be given to the oversight of all heating appliances; (first), to see that they are safely located and on good, substantial supports; (second), to see that they are well constructed, and where bracing or "tying" is necessary that the braces, anchors, rods, etc., are strong and well placed; (third), that they are kept in good condition, not used when broken or in any way in disrepair; (fourth), when fires are not needed that the appliances are left cold.

CHAPTER V.

LIGHTING.

ACETYLENE GAS MACHINES.—The installation of these machines is regulated by the local authorities in certain districts. (National Board of Fire Underwriters.) The use of liquid acetylene or gas generated therefrom is absolutely prohibited. The generator must be located in a well-ventilated room, in such a position that the operating mechanism shall have room for free and full play, and can be adjusted without the need of artificial light, and where there will be sufficient heat to prevent water from freezing. In no case shall it be nearer than 15 feet to any fire and 10 feet to any artificial light; it must never be placed in closets or where it will be subject to interference by children or careless persons, and if for this purpose further enclosure is deemed necessary, the enclosure shall be made of slatted partitions, permitting the free circulation of air. The generator must be set so that it is level, and so that unequal strain will not be placed on it or its connections, and if possible the foundation should be of brick, stone, concrete or iron, but if this is not possible and wood is used, it shall be of heavy planking, joist or timber, so arranged that the air will circulate about it, but whatever is used for a foundation must be firm and rigid. Each generator must be provided with an escape or relief pipe of at least ¾-inch internal diameter; this pipe must be substantially installed, without traps, and so that any condensation will drain back to the generator; it must be carried to a suitable point outside the building and terminate in an approved hood, located at least 12 feet above ground and remote from windows, the hood being constructed in such a way that it cannot be obstructed by rain, snow, ice, insects or birds. The capacity of the generator must be such that it will be capable of supplying gas continuously for at least five hours for all burners attached, and must be great enough to furnish gas continuously for all lights supplied and for the maximum lighting period; generators for conditions of service requiring lighting periods of more than five hours must be of sufficient capacity to avoid recharging at night. The following ratings will usually be found advisable:

1. For dwellings and where machines are always used intermittently, the generator should have a capacity sufficient to supply all of the burners attached.

2. For stores, opera houses, theaters, day-run factories, and similar service the generator should have a capacity of from 30 to 50 per cent in excess of the total capacity of the burners.

3. For saloons, all night or continued service, the generator should have a capacity of from 100 to 200 per cent in excess of the total capacity of the burners.

A small generator should never be installed to supply a large number of lights, even though it seems probable that only a few lights will be used at a time. An overworked generator adds to the cost of producing acetylene gas.

The carbide charge must be sufficient to furnish gas for all burners during the maximum lighting period; in determining charges the carbide to be estimated as containing 4½ cubic feet to the pound, and the burners as consuming at least 25 per cent. over rated burning capacity.

Burners consuming one-half of a cubic foot per hour are considered standard in rating generators.

Piping must be so arranged that any moisture will drain back to the generator, but if from necessity any low points occur they shall be drained through tees into drip cups; tees must not have any pet cocks but must be closed with screw caps or plugs. A valve and by-pass connection shall be provided from the service pipe to the blow-off for removing the gas from the holder, in case it should be necessary to do so. The scheme of pipe sizes for piping from generators to burners should conform to that commonly used for ordinary gas, but in no case shall the feeders be smaller than ⅜-inch. The following schedule is advocated:

Three-eight-inch pipe, 26 feet, three burners; ½-inch pipe, 30 feet, six burners; ¾-inch pipe, 50 feet, twenty burners; 1-inch pipe, 70 feet, thirty-five burners; 1¼-inch pipe, 100 feet, sixty burners; 1½-inch pipe, 150 feet, one hundred burners; 2-inch pipe, 200 feet, two hundred burners; 2½-inch pipe, 300 feet, three hundred burners; 3-inch pipe, 450 feet, four hundred and fifty burners; 3½-inch pipe, 500 feet, six hundred burners; 4-inch pipe, 600 feet, seven hundred and fifty burners.

In all cases it is desirable that generators be located outside of the buildings insured, and in cases of very large installations and in territory where underwriters having jurisdiction do not permit installation inside insured buildings, the following specifications are offered as suggestions for generator houses: In closely built-up districts generator house should be of brick, fireproof, and located as far as practical from other buildings; it should not open into or towards the insured buildings, and should be kept under lock and key; the dimensions to be no greater than the apparatus requires to allow convenient room for recharging and inspecting all its parts; the floor should be at least 12 inches above grade and the entire structure thoroughly weather proof and thoroughly ventilated, and if necessary to heat it, the heat should be supplied by steam, hot air or hot water. In outlying districts where the generator house can be located 25 feet or more from other buildings, fireproof construction is not especially necessary:

The following are necessary for the proper care and attention of the machines, etc.:

Generators designed to supply the rated number of burners for a longer period than five hours should be cleaned and recharged at regular stated intervals, regardless of the number of burners actually used.

Generators not intended for use throughout the entire year shall have all water and gas removed at the end of the season.

It is usually necessary to take the bell portion out and invert it so as to allow all gas to escape. This never to be done in the presence of artificial light or fire of any kind.

A regular time should be set for attending to and charging the apparatus during daylight hours only.

In charging generating chambers clean all residuum carefully from the containers and remove it at once from the building. Separate the unexhausted carbide, if any, from the mass and return it to the container, adding new carbide as required. Be careful never to fill the container over the specified mark, as it is important to allow for the swelling of the carbide when it comes in contact with water. The proper action and economy of the machine is dependent on the arrangement and amount of carbide placed in the generator. Carefully guard against the escape of gas.

Whenever recharging with carbide always replenish water supply.

Never deposit residuum or exhausted material from water feed machines in sewer pipes or near inflammable material.

Water tanks and water seals must always be kept filled with clean water.

Never test the generator or piping for leaks with a flame, and never apply flame to an outlet from which the burner has been removed.

Never use a lighted match, lamp, candle, lantern or any open light near the machine.

The failure to observe the above cautions is as liable to endanger life as property.

CANDLES should be placed in heavy bottomed candle holders, in order to keep them from falling over, or, they should be placed in lanterns. The latter way is preferable. They should never be carried around among loose inflammable materials where they are apt to come in contact with them, and should never be used outside of lanterns where there is any flying inflammable materials. The use of candles outside of lanterns is to be held as being dangerous.

COAL GAS.—Where there is a private system of production, the burner or furnace house should be detached from all other buildings, and preferably be built of skeleton iron frame, i. e., an open-sided iron shed.

(ELECTRIC LIGHTING.—See Chapter V.)

GASOLENE VAPOR GAS LIGHTING MACHINES, LAMPS AND SYSTEMS—(National Board of Fire Underwriters):

Class A.—Machines having outside carbureters. These machines, which do not introduce liquid gasolene into the building, are regarded from an insurance viewpoint as constituting the least dangerous type of gasolene gas machine.

Class B.—Machines having inside carbureters. These machines are regarded from an insurance viewpoint as more dangerous than those having outside carbureters, owing to the fact that they introduce gasolene in liquid form and manufacture gas inside the building. Where permitted the following rules and precautions should be rigidly observed.

Class C.—Gasolene oil distribution systems. These systems are regarded from an insurance viewpoint as more dangerous than the systems in Class A or Class B. Where used their hazards should be recognized by underwriters and the following rules and precautions should be rigidly observed.

Class D.—Gasolene vapor lamps. These lamps are regarded from an insurance viewpoint as even more dangerous than the systems covered in Class A, Class B or Class C, and where used their hazards should be recognized by underwriters in higher rates of premium.

Class E.—Especially hazardous systems. Gasolene vapor gas lighting machines or systems in which any of the following defects are inherent or in which the hazardous conditions which they represent are likely to obtain, introduce especially dangerous features which cannot be measured by any obtainable rate:

1. Machines which have no automatic control over either the quantity or quality of the gas supplied. 2. Systems in which it is possible to admit at one time more than one gallon of gasolene inside the building. 3. Machines in which a flame is used to vaporize gasolene. 4. Systems in which sheet metal piping is used to distribute gas. 5. Machines or systems in which air is drawn into the open end of the service pipe, as in a Bunsen burner. 6. Machines which require hand regulation as the number of burners in use is varied.

GASOLENE VAPOR GAS (National Board of Fire Underwriters).—Where there is an outside carbureter it must be at least 30 feet from any building, below the frost line and below the level of the lowest pipe in the buildings lighted; the blower must be set on a level foundation, with the weights so arranged, when weight-driven blowers are used, that they may be wound up at any time without affecting the pressure on the lights; must be automatic in action; the mixers must have no open connection to the outside air except through the blower; the pressure regulator must not depend upon springs for proper action. The piping from the carbureter to the building must not be located near, nor placed in the same trench with other piping;

must have an incline toward the carbureter of not less than 1 inch in 10 feet, must be laid on solid earth below the frost line and not on wooden blocks or sticks; fill, vent and transfer pipes extending to the surface of the ground must be boxed or provided with enclosing sleeves to prevent the freezing of the earth about them; openings for pipes through outside walls must be securely cemented and made water tight. The inside piping must incline in all cases toward the main riser, hence all horizontal branch pipes should rise from the floor below and not descend from the ceiling above, and in no cases must there be any sags, pockets or traps in the pipe; the air pipe from the pump must be carried at least 24 inches higher than the top of the filler pipe of the carbureter.

The following schedule of pipe sizes for gasolene vapor gas is advocated:

Size of	main	riser for	20 to 30	lights	1	inch.
"	"	"	40 to 50	"	1¼	"
"	"	"	75 to 100	"	1½	"
"	"	"	150 to 200	"	2	"
"	"	"	300	"	2½	"
"	"	"	500	"	3	"
"	"	"	750	"	4	"
"	"	"	1000	"	5	"

No riser in any building should be less than 1 inch inside diameter.

For branches the following table gives the proportionate sizes and lengths of branches:

Size of Pipe.	Greatest Length Allowed.	Greatest Number Lights.
⅜	15 feet.	3
½	20 "	6
¾	50 "	12
1	75 "	25
1¼	90 "	75
1½	125 "	100
2	150 "	200

No pipe used in any portion of the building, even though it is only to supply one light, should be less than ⅜-inch inside diameter.

GASOLENE VAPOR GAS (National Board of Fire Underwriters).—Where there is an inside carbureter the supply tank must be located outside of the buildings, and wherever possible at least 30 feet from all buildings, and below the level of the lowest pipe in the buildings in the system; where it is not possible to bury the tank it can be located in a non-combustible building or vault, properly ventilated; the fill and vent pipes must terminate in an iron box, cover of which should be flush with the ground and locked with a padlock. The carbureter must not contain more than one quart of gasolene at any one time, must have no valves opening into the room, must be provided with an overflow connection draining back to the supply tank; only hot water or steam to be used to produce rapid evaporation, and, in all cases, the heating and evaporating chambers must be entirely separate. Single plunger gasolene feed pumps must have a check valve as close to the pump as possible. The pipe connecting the supply tank and the carbureter must incline toward the former at least 1 inch in 5 feet, and this pipe must be at least one size larger than the supply pipe. All the other piping must be in conformity with the rulings under the outside carbureter system. A filler must be provided in the gasolene supply pipe as near the pump as possible, and accessible for the purpose of cleaning; a substantial flange fitting containing fine brass gauze is recommended for this purpose.

GASOLENE OIL DISTRIBUTING SYSTEMS.—The tanks and reservoirs must be located as per rulings for tanks where an inside carbureter is in use, and must be so arranged that under normal conditions the only gasolene in the building will be that contained in the pipe system and so that under no possible condition can more than one gallon of gasolene be accidentally admitted at one time within the building, and must be so placed that no artificial light will be required while filling, and must be provided with a pressure gauge and a shut-off valve. The distributing tubes must be run in wooden moulding or iron pipes inside of a building, and must not be held in place with staples; must not be concealed behind walls or ceilings, must not be nearer than 3 inches to electric wires, and where tubes cross wires, pipes or metal girders proper insulation must be provided. In order to control the supply of gasolene to all of the lamps on each floor and to each lamp, readily accessible shut-off valves must be provided. The lamps and burners must not be used in places where an undue amount of ignitable material may accumulate on them, or where there is inflammable dust or gas, or where there is loose inflammable material on the floor under them; must not be initially heated by the use of liquid gasolene, and in all cases they must be suspended from a rigid and secure support not liable to become weakened by vibration or continued use; must be of such length that the distance from the burner gauze to the point of support shall not be less than 20 inches, and must in all cases be provided with a metal heat deflector permanently secured to the frame.

GASOLENE VAPOR LAMPS.—The distance between the burner gauze and the top of the frame must not be less than 20 inches. For gravity lamps the reservoirs must not exceed two quarts capacity, and must be provided with a conspicuous filling indicator to show when the reservoir is nearly full. For pressure lamps the reservoirs must be so arranged so that not to exceed two quarts of gasolene can be supplied. The generators must have all parts accessible for purposes of cleaning. Shut-off valves must close against the gasolene supply. Metal heat deflectors must be attached to all pressure-feed lamps and to all gravity-feed lamps, and fixtures in which the distance from the burner gauze to the top of the frame is less than 30 inches, or in which the distance between the edge of the reservoir and the vertical center line of the generator is less than 6 inches; they must not be less than 4 inches in diameter, and must be secured in a substantial manner so as not to be readily removed.

KEROSENE OIL PRESSURE SYSTEMS—(National Board of Underwriters).—These systems used to supply kerosene vapor lamps, stoves, blow-torches and furnaces with oil under considerable pressure are regarded from an insurance viewpoint as much more hazardous than ordinary kerosene lamps or stoves. Where used, the following rules and precautions should be rigidly observed:

The supply tank should preferably be located outside, under ground and below the lowest level of the pipes in the building connected with the apparatus, but if inside of the building it must be in such a location that no artificial light will be required while filling it, and so arranged as not to be exposed within 15 feet of any stove or furnace; must be provided with a reliable pressure gauge, a shut-off valve, an air relief valve, and a fusible device to vent tanks in case of fire. Must not be used with an operating pressure of over 100 pounds per square inch, and must be marked with the name of its manufacturer.

The distributing tubes must be protected on side walls from mechanical injury and enclosed in places so exposed in iron pipe or approved moulding. Bushed staples should be used when tubing is not so protected, but in no case must it be concealed behind walls or ceilings. Must not be placed nearer than 3 inches to electric wires, and where tubes cross wires, pipes or metal girders, proper protection from mechanical injury must be provided. Must be provided with a readily accessible shut-off valve on each floor to control the supply of kerosene to all lamps or other devices on that floor, and must also be provided with a shut-off valve for each separate lamp, or other device in addition to the main valve as specified above. Joints must be made through solid brass fittings and must be threaded and soldered or else brazed together; there must be no connections depending upon gaskets, packing or washers to prevent leakage. Lamps must not be installed within 3 feet of combustible material, and must not be used in places where ignitable material may accumulate on them, or where there is inflammable dust or gases, or where there is loose inflammable material on the floor under them; must be suspended from a secure support not liable to become weakened by vibration or continued use; must be provided with a metal heat deflector, not less than 6 inches in diameter, rigidly secured to frame; must be of such length that the distance from the burner gauze to the point of support shall not be less than 30 inches; must be provided with a name plate or stamp giving the name of the lamp and its manufacturer.

OIL LAMPS.—Should not be used if possible. Metal oil cup or glass oil cups securely and fully set in metal cups are the least dangerous forms of lamps. An all-glass, unprotected lamp is an especially hazardous lighting appliance, and should be discarded wherever possible. All standing lamps should have heavy bases to prevent the tipping over of the lamp. Hanging lamps should have good substantial metal hangers, supported on reliable supports, so as to reduce the liability to fall to a minimum.

Lanterns.—Only such lanterns in which there is no possibility of the oil cup falling from the lantern should be used. Spring bottom lanterns present the liability of the bottom falling out through the weakening of the retaining springs. Side catch lanterns are not so apt to get out of order, but it is safer to use a lantern in which the oil cup is part and parcel of the frame and cannot be detached from it, such as the tubular, safety locked and bull's-eye patterns. All lanterns should always have wire guards around their globes in order to prevent the possibility of the globes being broken. A lantern with a broken globe should never be used.

NOTES.—The hazard here requires close attention, for, from the number of burners and the various kinds of illuminants used, the danger is distributed undiminished in very many places. Gas burners very generally swing against inflammable materials, or expose the woodwork above them, gases are apt to collect and explode, oil lamps are liable to break and scatter the oil, lamps and lanterns of poor construction, or out of order, and poor grades of oil all contribute immediate and many separate dangers.

One of the essential things in lighting by gas is the manner in which the carrying pipes and connections are installed; that they should be tight, and be kept so, so as to prevent any leakage, is of prime importance, and where there is any smell of gas the leak should be sought and remedied. Another thing is in the using of first-class fittings, brackets, etc., for in the use of inferior ones, through the handling of them, leaks are apt to develop and prove expensive.

Stationary gas brackets should be used wherever possible.

Swinging gas brackets liable to come in contact with inflammable materials should be provided with wire netting cages, or be made rigid by the use of wire or iron rods, or the inflammable material should be removed.

Where woodwork is apt to be affected by the direct flame of a light, it should be covered with asbestos, and over this a covering of sheet tin-locked joints, nailed on under the joints. If the woodwork is irregular in shape, the coverings should follow all the angles and lines closely. Where woodwork is exposed to the flame of a light, but not apt to be in direct contact with it, or where soot from the light will deposit on the woodwork, it should be protected by sheet metal with all the edges turned at right angles and towards the light, and so placed as to have an air space between it and the woodwork.

The lights for rooms in which there is ignitable gases or dusts (such as still rooms in distilleries, certain rooms in chemical and pharmaceutical laboratories, dust rooms of flour mills, lint blow rooms, etc.), must be placed outside of the room and illuminate the room through thick glass windows.

Where lights are used in rooms where there is flying lint, saw dust, or any such combustible loose flying materials, they should be enclosed in glass cases.

All lights should be extinguished when not actually needed.

Do not hunt a leaking gas pipe with a light.

Use such safety matches as light only on prepared surfaces. Matches whose heads snap off should not be used. Do not use parlor matches. Beware of loose matches on the floor. The supply of matches should be kept in tin boxes not raised very much from the floor level.

Gas meters should be located in a readily accessible place and where there is no hazard from inflammable materials.

In manufacturing plants oil lamps and lanterns should be filled in a special place, over a proper drip pan, by some responsible person appointed for that purpose, and by daylight only. One man should be assigned to do all the lighting of lamps, lanterns, gas, etc., in each room, and it should also be the duty of one person to see that all of the lights are properly extinguished; wax tapers, electric lighters and small hand lamps should be used for lighting in preferance to matches.

ILLUMINATING OIL.—A good illuminating oil is formed by mixing one gallon of 150 degs. to 175 degs. kerosene with two gallons of best lard oil. Illuminating oil should not flash under 110 degs.

The specifications of the United States Army defining kerosene require a flashing point between 135 degrees and 150 degrees Fahr. and a hydrometer test of 48 degrees Baume (specific gravity 0.7865).

STORAGE OF CALCIUM CARBIDE (National Board of Fire Underwriters).—Calcium carbide in quantities not to exceed 600 pounds when contained in approved packages holding not to exceed 100 pounds each, must be stored outside of insured property in a receptacle or enclosure under lock and key, and constructed as follows: (1) A waterproof structure or receptacle having the bottom raised at least twelve inches above the ground and located at least 10 feet from any building; or, (2) a movable magazine constructed of not less than No. 18 B. & S. gauge galvanized iron, the bottom to be fastened to side by 1½-inch angle-iron, the upper edge to be reinforced by a band iron, the whole to be waterproof and raised at least 4 inches above the ground and located preferably away from windows; or (3) a fire and waterproof brick structure opening away from the building, with floor raised at least 12 inches above the grade; or (4) in outside generator houses if not placed over cesspools or wells, and where located at least 10 feet from insured buildings.

Packages to be approved must not contain to exceed 100 pounds and must be made of metal, with seams lock-jointed and soldered. The package must be provided with a screwed top, or its equivalent, must be water-tight, of sufficient strength to insure handling without rupture, must be wood or iron-jacketed, and conspicuously marked "CALCIUM CARBIDE—DANGEROUS IF NOT KEPT DRY."

Where calcium carbide is stored in excess of 600 pounds, it must be stored above grade and in a building used exclusively for this purpose. Building must be thoroughly dry, waterproof, well ventilated, without artificial light or heat, and located as follows: (1) Brick or stone, fireproof buildings must be located at least 25 feet from any other buildings. (2) Buildings of other construction must be located at least 100 feet from any other buildings.

Calcium carbide in approved metal cans holding not to exceed two pounds each may be permitted inside of insured buildings when contained in an enclosed magazine or holder constructed in accordance with the following specifications: Must be of galvanized iron not less than No. 18 American gauge, and must have all seams lapped, riveted and soldered both inside and out, so as to protect edges and rivets from rust, and form thoroughly water-tight joints. Must be constructed so that the bottom will be raised at least six inches from the floor by means of ventilated rims. These rims to be reinforced where they come in contact with the floor by heavy iron bands and flared so that they will be at least six inches larger at the base than at the top. Must be closed at the top having a cover to form a water-tight joint by means of a single clamp, and all removable parts must be attached to the holder proper by chains or other approved method. Must be so proportioned in its dimensions that not more than 100 pounds of carbide in metal cans not exceeding 2 pounds each can be placed in any one holder. Must be kept above the grade of the street and plainly marked in letters at least 2 inches in height "CALCIUM CARBIDE—KEEP DRY." The cover must be marked "KEEP CLOSED." Cans containing not to exceed two pounds each must be made of metal. Joints not to rely on solder, and cans to be thoroughly water-tight.

CHAPTER VI.

ELECTRIC LIGHT AND POWER INSTALLATIONS.

In order to fully understand the hazards and purposes of various protective devices for electric installations some knowledge of the different appliances and connections is necessary.

Electricity used commercially is produced by mechanical means and hazards are inherent in all stages of production, transmission and use, hence every point from the generator to the lamp or motor needs attention, and should at all times be kept in perfect condition. Vibration, insecure fastenings, deterioration from wear and tear, carelessness in handling and in oversight and many other causes contribute to the hazards as much as an originally poor installation; the system needs care and attention at all times, and every point needing repairs should receive them as soon as the need is found. Procrastination here is the thief of the insurance company.

All the rulings of this chapter are in conformity with the 1901 "NATIONAL ELECTRIC CODE," RULES AND REQUIREMENTS of the National Board of Fire Underwriters for the installation of electric wiring and apparatus, as recommended by the Underwriters' National Electric Association. Edition of 1901.

GENERATORS AND DYNAMOS.—These machines are made for generating or producing electric currents, are propelled by some separate mechanical power, and are composed of the following parts:

Field Magnets.—Electro-magnets composed of soft iron bars, or bundles of iron, or solid iron castings around which insulated wire is closely wound; being electro-magnets, they are only polarized while currents of electricity are passing through them, and while some of them hold sufficient magnetism to produce a current as soon as the dynamo is started, others need an "exciter," and in some cases, another dynamo is used to produce the initial magnetism, as it is necessary that the magnets be in a state of magnetism before a current can be produced. Dynamos are either of one magnet, North and South pole, or multipolar, consisting of a number of magnet poles, generally on a circular shaped field magnet radiating toward the center.

Armature.—This is made of mass or piece of iron or steel, on a collection of pieces of iron or wire carrying independent coils of insulated wire in sections, and is between the field magnets. The space between the field magnets and the armature is called the field, and it is by the rotation or motion of the armature in this field, or by the field magnets rotating about the armature that the electric current is produced.

Commutator.—The ends of the wire from each section of the armature are run to one end of the armature shaft (the wires being thoroughly insulated from each other, from every other wire and from the shaft), and are here connected to a copper cylinder or a series of copper strips in sections, with alternating sections of non-conducting material between, this copper section being the commutator.

Brushes.—Resting upon the commutator are the brushes; these are of different forms but usually of copper (a bundle of strips, layers of woven netting, wires in bundles, etc.); carbon rods or slabs are also used.

The current is produced by the rotation of the armature in the field, or the rotation of the field magnets, about the armature, and is led off through the armature to the commutator and here taken up by the brushes to be carried thence by the conductors to the outside lines. The currents generated are of two kinds, *i. e.*, alternating, reversed, or periodic where the current alternately flows in opposite directions and in which the potential is high, usually from 1,000 to 10,000 volts, and direct or constant in which the potential is high or low, but the current flows invariably in one direction. Certain types of alternating currents, in which the currents flowing in opposite directions, constantly differ from each other by a constant proportion of periods of alternation, produced by the method of winding the armature, are called polyphase, multiphase or rotary currents.

Location and Hazards.—As moisture tends to cause a degeneration in the insulation of the wires and so allow a leakage of current which is liable to produce such overheating as to seriously damage the dynamo, it is necessary that the location be dry, and that a waterproof cover be kept on the dynamo when not running, in order to prevent moisture falling on it; the cover also tends to keep any flying inflammable materials from collecting on the dynamo. In order to prevent any liability of a ground occurring and presenting the possibility of the armature burning out from the heat produced, the dynamo should be thoroughly insulated from earth, walls, floors and all metallic substances and set on a wooden base frame filled to prevent absorption of moisture; the base frame must be kept clean, dry and free from oil and metal dust, as these tend to form a line of conductivity for the current. There is always more or less of a tendency to spark, *i. e.*, to produce sparks, in a dynamo, and as the sparks frequently have a sufficient intensity of heat to produce combustion, it becomes particularly necessary to locate the dynamo in some room wherein no hazardous process is carried on nor where there is any liability to be any inflammable gases or flying combustible material.

Every constant-potential generator must be protected from excessive current by a safety fuse, or equivalent device, of approved design in each lead wire.

A high-potential machine which, on account of great weight or for other reasons, can not have its frame insulated from the ground, should be surrounded with an insulated platform. This may be made of wood, mounted on insulating supports, and so arranged that a man must always stand upon it in order to touch any part of the machine.

In case of a machine having an insulated frame, if there is trouble from static electricity due to belt friction, it should be overcome by placing near the belt a metallic comb connected with the earth, or by grounding the frame through a very high resistance of not less than 300,000 ohms.

Welding Dynamos.—These are of the alternating type and must be installed with all the care used for any dynamo of like voltage and capacity.

Electrolysis and Plating Dynamos.—These are of the constant current type, and although often of low voltage are of great volume, hence must be thoroughly insulated from combustible material.

Storage or Primary Batteries.—These batteries are used for storing up electricity and are highly charged; it thus becomes necessary to prevent any leakage of electricity by water on the sides of the jars, etc., to the ground, or burning out of connections on account of using any metals liable to corrosion in them (for the batteries being highly charged and being liable to give off a greater current than rated for, if the connections become corroded and thus weakened, they are apt to be burned out by the current); hence it is that the batteries must be mounted on glass or porcelain insulators and that their connections must not be made with any metal subject to corrosion.

In charging the batteries explosive gases are apt to be formed from the action of the current; it is therefore necessary to have the batteries located in well ventilated places. The same regulations as apply to similar apparatus fed from dynamo generators developing the same difference of potential must be observed with batteries.

SWITCH BOARDS AND SWITCH BOARD APPARATUS.—Switch Board. From the brushes the wires or conductors carry the electric current to the switch board, where are located the measuring, regulating and distributing apparatus. Here the hazards are from moisture forming arcs, from the arcs formed when the switches carrying currents are opened, where large fuses are on the board from the hot metal thrown or falling in event of a fuse melting, from over-heated rheostats and from defective instruments producing and holding arcs; hence the board should be made of some non-combustible material (such as the best polished white marble, free from cracks and metallic veins, or the best of slate free from metallic veins supported on iron framing), or of a solid, heavy, skeleton frame of hardwood, filled to prevent absorption of moisture. The board must have a clear space of eighteen inches between it and the floor, two feet between it and any ceiling which is not fireproof, and when connections are on the back of it must be accessible from all sides; if the connections are on the face of the board it may be placed against a brick or stone wall; the board must also be so located as to be free from moisture, and as to reduce to a minimum the danger of communicating fire to adjacent combustible material.

Conductors from generators to switchboard, rheostat or other instruments, and thence to outside lines must be in plain sight and readily accessible and must be properly covered with an approved insulating material, and where in central stations, on exposed circuits, the wire which is used must have a heavy braided non-combustible outer covering.

Bus Bar; also called Bus Rod, Bus Wire.—A large copper conductor which takes the current from several dynamos and passes it to the distributing leads; the bar is bare, no insulation covering being called for. The bars must be kept so rigidly in place that they cannot come in contact. As the bar is subject to overheating, it must be mounted on glass or porcelain insulators on the face of the board. In a 2-wire system there are 2 bars, and in a 3-wire system 3 bars.

Rheostat, also called Resistance Box.—An apparatus for changing the resistance without opening the current and is generally built up of a number of resistance coils of iron or German silver set in a frame, and each one connected to one of a series of brass contact points set in a circle, or arc, on the face of the frame; a pivotal arm of brass is so set as to move over and in touch with the series of contact points, and it is by the moving of this arm that the proper amount of resistance is introduced into the circuit; the resistance is in reality an opposition to the free flow of the current, and this opposition is the cause of a considerable energy being dissipated in the form of heat, consequently there is a very considerable liability to the production of combustion in near by material; to reduce this hazard, no inflammable materials must be near the coils, hence the rheostat frame, meaning the entire case, must be of some non-combustible material, and if the rheostat is not on the switch board it must be placed at a distance of a foot from combustible material, or separated therefrom by a non-inflammable, non-absorptive insulating material, such as asbestos or glass, and it is much safer in the latter case to cover the combustible material with asbestos and then mount the rheostat on glass insulators over the asbestos.

Voltmeter.—A register for measuring the voltage of electromotive force, and is usually placed on the switch board so as to be readily seen. There is no special hazard to it.

Ampere-Meter, also called Ammeter.—A register for measuring the amperage or current throughout the entire line or circuit, and indicates the amount of current given out by the generator, and shows instantly if there is any undue load, such as would be produced if too many lamps were put in circuit, or if there was a serious loss of current from poor insulation of wires. A reliable ammeter clearly marked to show the full load of the machine should be placed in the armature circuit of each constant potential generator, so that the liability of the destruction of the generator by overloading, short circuit, grounds, etc., may be seen in time and obviated. There is no special hazard with this meter.

Switches.—These are for throwing in and out all the circuits, and must be double pole, have non-combustible bases, and be mounted on the face of the board.

LIGHTNING ARRESTERS.—Overhead wires entering a generating station require special provisions to arrest any lightning discharge which may seek to use them as a line of conductivity, as, if not thoroughly provided for, the atmospheric electricity would pass through switches, over fuses, through the dynamo, and then ground, producing a burning out of instruments and dynamo, and very probably a fire in any nearby combustible material; it is, therefore, necessary to provide a lightning arrester for each side of every such circuit, placing it, if possible, on the outside of the building, or, where not so placed, placing it as near as possible to the entrance of the wire into the building; the arrester must be mounted on a non-combustible base in a readily-accessible place, isolated from all combustible materials, and connected with at least two earths by straight wires without any kinks or coils, not smaller than No. 6 B. & S. (0.162 inches), and not in contact with any pipes or other metal within the building; the arrester must be so constructed as not to maintain an arc after the discharge has passed.

In all cases, kinks, coils and sharp bends in the wires between the arresters and the outdoor lines must be avoided as far as possible.

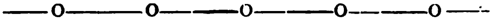
MOTORS.—The construction of a motor is similar in its parts to that of a dynamo, the only difference between them being in the manner of winding the wire. The difference in their action is that, whereas mechanical energy is used to produce an electrical current in a dynamo, the reverse is brought forward in a motor, for here an electrical current is used to produce mechanical energy. In consequence of the similarity of motors and dynamos, the dangers are identical, consequently all rulings pertaining to dynamos hold with equal value as regards motors.

Rheostat.—The motor should be in full view from the rheostat, so that in starting the motor it will always be in sight in case of any derangement occurring.

Switch.—Where the motor is over one-quarter horse-power, a double-pole switch must be so placed as to protect both the rheostat and motor.

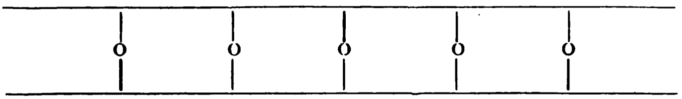
Cut-out.—A double pole, or two single, cut-out must be located in similar manner to the switch, so as to afford protection against excessive current. The ordinary lightning fuse blocks are not desirable for this work, as the distances are too short, and an arc started will maintain, as the hot block in connection with the metal tips will furnish an excellent conducting path; these fuses ought to have about an inch in length for each hundred volts used.

CIRCUITS.—Series. Arranged in succession. When lamps are arranged in succession in a circuit, so that the current goes through one after the other, they are said to be in series. A constant current with a variable pressure is generally used.



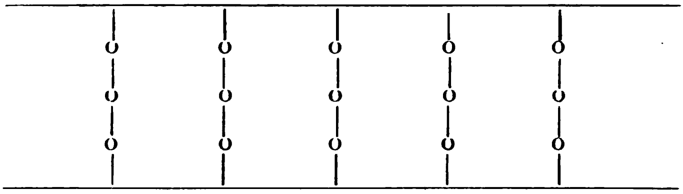
SERIES CONNECTION.

Multiple.—Ordinary incandescent lamp circuits are usually connected in multiple; that is, the lamps are arranged parallel with each other.



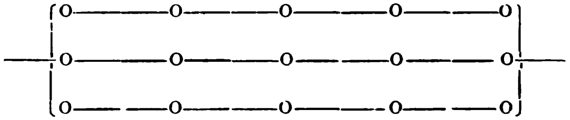
MULTIPLE CONNECTION.

Multiple Series.—The arrangement of electric apparatus in a circuit in a number of series, which minor series are then arranged in parallel. There is a special hazard here in overloading the dynamo by throwing in more series than the capacity of the generator will stand, and thus either burn out the armature or all of the generating apparatus by a short circuit. A variable current and constant pressure is used.



Multiple Series Connection.

Series-Multiple.—The lamps are arranged in series, in parallel, and the series connected. This is the most hazardous way of lighting, as by an accident to one lamp in a series an increased current must be taken care of by the remaining lamps of that series and a burning out of lamps, connections and circuit is apt to follow, and the thrown hot metal, etc., is liable to cause fire. The current is a constant one.



Series-Multiple Connection.

No system of multiple-series or series-multiple for light or power will be approved on high-potential system.

WIRING.—In generator rooms, the wires to and from generators, switch board, rheostats or other instruments and thence to outside lines are especially a source of danger, as in case of any arc, short circuit, ground or contact with wire of a higher potential anywhere in the circuit the whole capacity of the system would be concentrated in them and an excess of heat energy developed, hence they must be in full sight, readily accessible, wholly on glass or porcelain insulators and kept rigidly apart. As the vibration of a building or conductor is apt to abrade the insulation of the wire where it passes through walls, floors or partitions, it becomes necessary to prevent contact between the conductors and walls, floors and partitions by the use of glass or porcelain tubes; wash water on a floor is liable to collect around a conductor passing through the floor and cause a deterioration of the insulation of the conductor, hence the further need of insulator tubes.

Outside Work, All Systems and Voltages.—These wires are liable by coming in cantact with other conductors, by a break in a wire, by sagging, by moisture or some other accidental cause, to produce a ground or short circuit with the consequent damage to dynamos and appliances; it is therefore necessary that they be firmly secured to properly insulated and substantially built supports (the tie wires to have an insulation equal to that of the conductors they confine), be so placed that moisture cannot form a cross connection between them, not be less than a foot apart, and not in contact with any substance other than their insulating support. Service wires must have an approved rubber insulating covering, and line wires, other than service, must have an approved weatherproof, or rubber insulating covering. Service blocks must be covered over their entire surface with at least two coats of waterproof paint. To prevent contact with roofs by sagging the wires must be run at least 7 feet above the highest point of any flat roof and at least one foot above the ridge of any pitched roof over which they may run or to which they may be attached. Dead insulated guard irons or wires must be so placed as to prevent the wire falling in case of an accident to insulator, and to prevent contact with other conducting wires or substances to which currents may leak; special precautions of this kind must be taken where sharp angles occur, or where any wires might possibly come in contact with electric light or power wires. As the petticoat, glass or porecelain, insulator offers less chance of a leakage of current due to moisture, it is the only one approved. Where entering a building from outside, terminal insulators must be provided with drip loops (i. e., loops made in the wires between the insulators and the entrance holes in the building; these are for the purpose of providing points for collecting and dropping any water that may collect on the wire before it can enter the building); the holes through which the conductors pass must be bushed with non-combustible, non-absorptive insulating tubes slanting upward toward the inside.

Telegraph, telephone and similar wires must not be placed on the same cross-arm with electric light or power wires, and when placed on the same pole with such wires the distance between the two inside pins of each cross-arm must not be less than 26 inches.

Inside Work, All Systems and Voltages—General Rules.—The hazards are principally from poor insulation, small-sized wires, moisture degenerating the quality of the insulation, from conductors being too close to each other, poor joints, contact with wood or any other substance than insulating materials, all of which are apt to produce short circuits, grounds or arcs and speedily produce fire.

Table of Carrying Capacity of Wires.

B. & S. G.	Table A. Rubber-Covered Wires. Amperes.	Table B. Weatherproof Wires. Amperes.	Circular Mills.
18	3	5	1,624
16	6	8	2,583
14	12	16	4,107
12	17	23	6,530
10	24	32	10,380
8	33	46	16,510
6	46	65	26,250
5	54	77	33,100
4	65	92	41,740
3	76	110	52,630
2	90	131	66,370
1	107	156	83,690
0	127	185	105,500
00	150	220	133,100
000	177	262	167,800
0000	210	312	211,600
Circular Mills.			
200,000	200	300	
300,000	270	400	
400,000	330	500	
500,000	390	590	
600,000	450	680	
700,000	500	760	
800,000	550	840	
900,000	600	920	
1,000,000	650	1,000	
1,100,000	690	1,080	
1,200,000	730	1,150	
1,300,000	770	1,220	
1,400,000	810	1,290	
1,500,000	850	1,360	
1,600,000	890	1,430	
1,700,000	930	1,490	
1,800,000	970	1,550	
1,900,000	1,010	1,610	
2,000,000	1,050	1,670	

No wires smaller than No. 14 B. & S. are allowed except for flexible cords and in fixture work; tie wires must have an insulation equal to the conductors they confine, joints must be properly made, stranded wires must be soldered before being fastened under screws or clamps, and when they have a greater conductivity than No. 10 B. & S. copper wire they must be soldered into lugs; there must be no contact with walls, floors, timbers or partitions through which they may pass, but the wires must be separated from all such places by non-combustible, non-absorptive insulating tubes, such as glass or porcelain, and in no case must they be in contact with gas, water or metallic piping or any other conductor or conducting material which they may cross, but must be kept free from such by some continuous and firmly-fixed non-conductor, creating a separation of at least one inch, and where run in wet places an air space must be left between all conductors and pipes in crossing; the wires should be run over rather than under pipes, and must be so placed and run that they cannot come in contact with pipes accidentally. Where underground wires are brought into a building they must be protected against moisture and mechanical injury, and all combustible materials must be kept away from them and from their immediate vicinity, and they must be so arranged as to shunt the current through the building around any catch-box.

The lower limit is specified for rubber-covered wires to prevent gradual deterioration of the high insulations by the heat of the wires, but not from fear of igniting the insulation. The question of drop is not taken into consideration in the above tables.

The carrying capacity of sixteen and eighteen-wire is given, but no smaller than fourteen is to be used, except in fixture work and in flexible cords.

For insulated aluminum wire the safe carrying capacity is 84 per cent of that given in the foregoing tables for copper wire with the same kind of insulation.

Constant-Current Systems; Principally Series Arc Lighting.—Wires must have an approved rubber insulating covering, must leave and enter the building through an approved double-contact service switch, mounted in a non-combustible case, kept free from moisture and easy of access. They must always be in plain sight, be supported on glass or porcelain insulators, which separate them at least one inch from the surface over which they are run, must be kept rigidly at least 8 inches from each other, except within the structure of lamps, on hanger boards, in cut-out boxes, or like places where a less distance is necessary; must, on side walls, be protected from mechanical injury by a substantial boxing, retaining an air space of one inch around the conductors, closed at the top (the wires passing through bushed holes), and extending not less than 7 feet from the floor; when crossing floor timbers in cellars or in rooms, where they might be exposed to injury, wires must be attached by their insulating supports to the under side of a wooden strip not less than one-half an inch in thickness.

Low-potential systems, that is, any circuit attached to any machine, or combination of machines, which develops a difference of potential between any two wires of over ten volts and less than 550 volts, shall be considered as a low-potential circuit, and as coming under this class, unless an approved transforming device is used, which cuts the difference of potential down to ten volts or less. The primary circuit not to exceed a potential of 3,500 volts.

Wires must not be laid in plaster, cement or similar finish, nor be fastened with staples, nor be fished for any great distance, and must be protected on side walls from mechanical injury, and where crossing floor timbers in cellars or in rooms where they might be exposed to injury they must be attached by their insulating supports to the under side of a strip of wood not less than one-half inch in thickness and not less than 3 inches in width; twin wires must never be used except in conduits or where flexible conductors are necessary.

For open work in dry places the wires must have an approved rubber or "slow-burning" weatherproof insulation, must be rigidly supported on non-combustible, non-absorptive insulators, which will separate the wires from each other and from the surface wired over in accordance with the following table:

Voltage.	Distance from Surface.	Distance Between Wires.
0 to 300	½ inch	2½ inch
300 to 550	1 "	4 "

Rigid supporting requires under ordinary conditions, where wiring along flat surfaces, supports at least every 4½ feet. If the wires are liable to be disturbed, the distance between supports should be shortened. In building of mill construction, mains of No. 8 B. & S. wire or over, where not liable to be disturbed, may be separated about 4 inches, and run from timber to timber, not breaking around, and may be supported at each timber only.

This rule will not be interpreted to forbid the placing of the neutral of a three-wire system in the center of a three-wire cleat where the difference of potential is not over 300 volts, provided the outside wires are separated 2½ inches.

For open work in damp places, such as breweries, sugar houses, packing houses, stables, dye houses, paper or pulp mills, or buildings specially liable to moisture or acid or other fumes liable to injure the wires or their insulation(except where used for pendants) wires must have an approved rubber insulating covering; must have no joints or splices and must be rigidly supported on non-combustible, non-absorptive insulators which separate the wire at least 1 inch frôm the surface wired over, and they must be kept apart at least 2½ inches for voltages up to 300, and 4 inches for higher voltages. Rigid supporting requires, under ordinary conditions, where wiring over flat surfaces, supports at least every 4½ feet. If the wires are liable to be disturbed, the distançe between supports should be shortened. In buildings of mill construction, mains of No. 8 B. & S. wire or over, where not liable to be disturbed, may be separated about 4 inches, and run from timber to timber, not breaking around, and may be supported at each timber only.

Wires must never be placed in moulding, in concealed or damp places, or where the difference of potential between any two wires in the same moulding is over 300 volts, and in conduit work must not be drawn into the conduits until all mechanical work on the building has been completed as far as possible, and where the alternating system is used the two or more wires of a circuit must be drawn in the same conduit.

For concealed "knob and tube" work the wires must be rigidly supported on non-combustible, non-absorptive insulators which separate the wire at least 1 inch from the surface wired over.

Rigid supporting requires, under ordinary conditions, where wiring along flat surfaces, supports at least every 4½ feet. If the wires are liable to be disturbed the distance between supports should be shortened. Must be kept at least 10 inches apart, and, when possible, should be run singly on separate timbers or studdings; must be separated from contact with the walls, floor timbers and partitions through which they may pass by non-combustible, non-absorptive insulating tubes, such as glass or porcelain. When from the nature of the case it is impossible to place concealed wiring on non-combustible supports of glass or porcelain, an approved armored cable with single or twin conductors may be used where the difference of potential between conductors is not over 300 volts, provided it is installed without joints between outlets, and the cable armor properly enters all fittings and is rigidly secured in place; or, if the difference of potential between wires is not over 300 volts, and if the wires are not exposed to moisture, they may be fished on the loop system if separately incased throughout in flexible or approved conduits. Conduit used for mixed concealed knob and tube and conduit work must be continuous from outlet to outlet, comply with rules covering interior conduits, and must at outlets for combination fixtures be bushed with approved flexible insulating tubes, extending in continuous lengths from the last porcelain support to 1 inch beyond the outlet, except that an approved outlet insulator may be used. At outlets where there are no gas pipes, either this class of construction or porcelain bushing tubes may be used.

For Fixture Work.—Wires must not be less in size than No. 18 B. & S., and when on the outside of the fixture must be so secured as not to be cut or abraded by the pressure of the fastening or the motion of the fixture.

Interior Conduits.—These are tubes for the purpose of carrying wires, and are used on account of the facilities they afford for the insertion and extraction of the conductors, and to prevent any mechanical injury or injury by moisture to the insulation of the wiring; they are lined with insulating material or are made of insulating material, but all wires run through them must be insulated the same as conductors in other places; the conduits must first be run, continuously, from one junction box to another or to fixtures, and thoroughly installed as a system free from danger of injury by any nails, saws, chisels, etc., before conductors are placed in them; at each outlet they must be provided with an approved outlet box or plate, and where metal conduits enter junction boxes, and at all other outlets, etc., they must be supplied with a capping of approved material fitted so as to protect the wire from abrasion; the metal of the conduit must be permanently and effectually grounded.

High-Potential Systems, that is, any circuit attached to any machine or combination of machines, which develops a difference of potential, between any two wires, of over 550 volts and less than 3,500 volts, shall be considered as a high potential circuit, and as coming under that class, unless an approved transforming device is used, which cuts the difference of potential down to 550 volts or less. The wires must have an approved rubber insulating covering, must be in plain sight, never encased, and must be rigidly supported on glass or porcelain insulators, which raise the wire at least one inch from the surface wired over, and must be kept about 8 inches apart. Under ordinary conditions for rigid supporting, the supports where the wiring is over flat surfaces should be every 4½ feet, but if the wires are apt to be disturbed the supports should be closer together. In buildings of mill construction, mains of No. 8 B. & S. wire or over, where not liable to be disturbed, may be separated about ten inches and run from timber to timber, not breaking around, and may be supported at each timber only. The wires must be protected on side walls from mechanical injury by a substantial boxing, retaining an air space of one inch around the conductors, closed at the top (the wires passing through bushed holes) and extending not less than 7 feet from the floor; when crossing floor timbers, in cellars or in rooms, where they might be exposed to injury, wires must be attached by their insulating supports to the under side of a wooden strip not less than one-half an inch in thickness.

Extra High-Potential Systems, that is, any circuit attached to any machine or combination of machines, which develops a difference of potential, between any two wires, of over 3,500 volts, shall be considered as an extra high-potential circuit, and as coming under that class, unless an approved transforming device is used, which cuts the difference of potential down to 3,500 volts or less.

The primary wires must not be brought into or over building, except power and sub-stations, and the secondary wires must be installed under the rules for high-potential systems when their immediate primary wires carry a current of over 3,500 volts, unless the primary wires are entirely under ground within city, town and village limits.

SWITCHES.—These are instruments set in a circuit for the purpose of opening and closing the circuit, that is, to allow the current to flow through the circuit when the switch is closed and to make such a break in the circuit by opening the switch that the current is prevented from going through the circuit; the principle of their construction is that of two brass or copper sections or contact pieces, one being connected to one terminal wire of a circuit and the other terminal wire being connected to the second contact piece; one contact piece is stationary, while the other is movable, thus readily allowing contact between the sections to be made or broken; when the contact pieces are touching each other the switch is closed and the current passing through the circuit, otherwise the switch is open and the current broken.

All service switches must indicate on inspection whether the current be "on" or "off."

Automatic Switch.—This switch is opened or closed by a current of electricity magnetizing one or more electro-magnets; on an arc light it is used for the purpose of shunting the current around instead of through the lamp if the carbons fail to feed properly; it is also used for turning on the current to electric lamps at a distance and is then operated by a push button.

Double Pole Switch.—A switch having a double set of contact pieces.

Knife, Knife-Edge, Jack-Knife Switch.—A switch in which the movable arm is a thin wide piece of brass or copper which fits into two metal spring pieces, brass or copper contact pieces, edgewise. These switches whether provided with friction or spring stops must be so placed that gravity will tend to open them.

Snap Switch.—A switch in which the movable arm is operated by a finger piece and which is made positive in its opening and closing by a spring. Flush, push-button, door, fixture, incandescent lamp switches are of this pattern, and they must all "make" and "break" with a quick snap, and not stop when motion has once been imparted by the button or handle.

A Switch Automatic in Action is one so arranged that when the handle is once started it will not stop between points; thus there is no danger of a space being left for an arc to form it.

Arc Lamp Switches should preferably be double pole.

Lamps on Flexible Cords must, as far as possible, be controlled by switches placed on the walls.

Hazards.—When switches carrying currents are opened, there is always an arc formed, and if the current is of a high potential, the resultant heat is liable to melt a slow-moving or inferior switch, and if the switch is mounted on any combustible material a fire is the result, hence the bases of all switches must be of some non-combustible material, such as marble, slate, glass or porcelain; these bases are also non-absorptive and will thus prevent any arc forming from wet bases. A switch which does not have a firm and perfect contact when closed will maintain an arc, and to prevent this all switches must make firm and secure contacts and make and break (*i. e.*, open and close) readily and not stop when motion has once been imparted to the handle.

Switches should be grouped in one place as much as possible, must have carrying capacity sufficient to prevent heating and should be in dry and accessible places and in full sight.

Switches, Cut-Outs, Circuit-Breakers, etc., must be so arranged that the cut-outs will protect, and the opening of the switch or circuit-breaker will disconnect, all of the wires; that is, in a two-wire system the two wires, and in a three-wire system the three wires, must be protected by the cut-out and disconnected by the operation of the switch or circuit-breaker, and must not be placed in the immediate vicinity of easily ignitible stuff or where exposed to inflammable gases or dust, or to flyings of combustible material. In buildings used for starch and candy factories, woodworkers, grain elevators and flouring mills or other purposes where fittings are exposed to dust and flyings of inflammable material, cut-outs and switches should be placed in an approved cabinet outside of the dust-rooms, or, if necessary to locate same in dust-room, cabinet must be dust proof and arranged with self-closing door, and, when exposed to dampness, either be inclosed in a waterproof box or mounted on porcelain knobs.

Switches on Constant-Potential Systems must be placed on all service wires, either overhead or under ground, in a readily accessible place, as near as possible to the point where the wires enter the building, and arranged to cut off the entire current, and must always be placed in dry, accessible places, and be grouped as far as possible. Knife switches must be so placed that gravity will tend to open rather than close the switch. Must not be single pole when the circuits which they control supply devices which require over 660 watts of energy, or where the difference of potential is over 300 volts, and where flush switches are used, whether with conduit systems or not, the switches must be inclosed in boxes constructed of or lined with fire-resisting material (this requires an approved box in addition to the porcelain inclosure of the switch). No push-buttons for bells, gas lighting circuits or the like shall be placed in the same wall-plate with switches controlling electric light or power wiring. Where possible, at all switch or fixture outlets, a ⅞-inch block must be fastened between studs or floor timbers flush with the back of lathing to hold tubes, and to support switches or fixtures. When this cannot be done wooden base blocks, not less than ¾-inch in thickness, securely screwed to lathing, must be provided for switches, and also for fixtures which are not attached to gas pipes or conduit tubing.

Switches for Constant-Current Systems must close the main circuit and disconnect the branch wires when turned "off"; must be so constructed that they shall be automatic in action, not stopping between points when started, and must prevent an arc between the points under all circumstances. They must indicate, upon inspection, whether the current be "on" or "off."

No Electro-Magnet Device for Switches is permitted for incandescent lamps in series circuit.

CUT-OUTS.—(Automatic cut-outs, fuses, circuit-breakers.) Appliances for making a break in an electric circuit so as to interrupt the flow of the current, and are for the purpose of preventing the current passing when from any cause it may be of so high a potential as to cause overheating in any portion of the circuit; when they are automatic in action, they are constructed with a strip of fusible metal set in between the terminals of a conductor for the purpose of melting at a determined carrying capacity of current and thus, in case of an overloading, automatically, by melting, break the circuit.

Cut-outs must be so constructed that the fusible strip or wire is so proportioned to the conductors they are intended to protect, that they will melt before the maximum safe-carrying capacity of the wire is exceeded, and be long enough, so that after melting, an arc cannot form across the space between the terminals. Overheating in the conductors may be caused by grounds, short circuits, overloading the wires by currents of too high potentials, etc., hence cut-outs are very essential in all circuits, and as the melting point is at the cut-out, it is necessary that the base of the cut-out should be of some material not affected by heat, nor should it be absorptive of moisture, as the moisture would be liable to cause a ground, hence the bases of all cut-outs must be of glass, porcelain, marble or slate. When a cut-out burns out there is an excess of heat generated and hot metal thrown around, consequently all cut-outs should be placed in cabinets, so constructed and with the cut-outs so arranged in them, as to obviate any danger of the melted metal coming in contact with any substance which might be ignited thereby; the cabinet should be of marble, slate, or of wood, lined with a non-combustible material such as asbestos or slate, with a tightly fitting door of the same construction as the cabinet, or with a heavy plate-glass not less than three-sixteenths of an inch in thickness; a space of several inches should be left between the fuses and the door, especially if the door is of glass; the bushings through which the wires enter the cabinet must tightly fit the holes, and the wires should tightly fit the bushings; tape can be used to build up the wires to fit the bushings. It is good policy to, as far as possible, group all cut-outs at one place.

Double Pole Cut-Outs have two fusible strips, one for each wire in a two-wire system, and three in a three-wire system. In place of using a double-pole cut-out, single-pole cut-outs for each wire can be used. Double-pole cut-outs should be located at every point where a change is made in the size of the wire (unless the cut-out in the larger wire will protect the smaller).

Constant-Potential Dynamos should have a safety fuse located in each conductor, of such a size that they will melt before the armature could be affected. These fuses can be mounted on the switchboard, but preferably they should be on the dynamo.

Constant-Potential Systems must have automatic cut-outs, fuses, or circuit-breakers on all service wires, either overhead or underground, as near as possible to the point where they enter the building and inside the walls, and arranged to cut off the entire current from the building, must be placed at every point where a change is made in the size of the wire, unless the cut-out in the larger wire will protect the smaller, be in plain sight, or inclosed in an approved box and readily accessible, must not be placed in the canopies or shells of fixtures, must be so placed that no set of incandescent lamps, whether grouped on one fixture or several fixtures or pendants, requiring more than 660 watts, shall be dependent upon one cut-out, and must be provided with fuses, the rated capacity of which does not exceed the allowable carrying capacity of the wire; and, when circuit-breakers are used, they must not be set more than about thirty per cent above the allowable carrying capacity of the wire, unless a fusible cut-out is also installed in the circuit.

CLEATS.—These are supports for wires, having grooved places in them for each separate wire. As there is more or less vibration in buildings, especially those containing moving machinery, if the cleats are not put up firmly the insulation of the wire is apt to be abraded; and if there is any moisture in a room where wooden cleats are used, the cleats will probably become wet—the dangers of arcs and short circuits are apparent; hence it is that only porcelain cleats should be used.

ROSETTES.—These are devices containing fuse strips for hanging flexible cord from; as excessive heat is liable to be generated in them and hot melted metal be dropped it is required that rosettes be made of porcelain or some non-combustible and non-absorptive material.

ARC LAMPS.—The light is produced by a voltaic arc between carbon electrodes placed in such positions, generally vertical, that an end of one is directly opposite the end of the other; special mechanism, operated partly by springs, by gravity, and partly by electricity, is employed to regulate the distance between the carbons; when no current is on, the carbons touch, and, as soon as the current passes, the carbons separate.

The carbons in these lamps chip and break through the action of the heat generated, and these white-hot chips, or sparks, are thrown, or dropped, off, or, when copper-plated carbons are used, the melted metal drops, and the heated carbons are also liable to become loose and fall; hence the hazards from the carbons are great, and it becomes necessary to provide all lamps inside of buildings with globes, surrounding the arcs, fastened securely upon a closed base; no cracked or broken globes allowed under any circumstances; must be provided with a wire netting (having a mesh not exceeding 1¼ inches) around the globe, and an approved spark arrester when readily inflammable material is in the vicinity of the lamps, to prevent escape of sparks, melted copper or carbon. It is recommended that plain carbons, not copper-plated, be used for lamps in such places.

Arc lamps, when used in places where they are exposed to flyings of easily inflammable material, should have the carbons enclosed completely in a globe in such manner as to avoid the necessity for spark arresters.

For the present, globes and spark arresters will not be required on so-called "inverted arc" lamps, but this type of lamp must not be used where exposed to flyings of easily inflammable materials.

Where hanger-boards are not used, lamps must be hung from insulating supports other than their conductors, and all lamps must be carefully insulated from any circuit in all of their exposed parts.

Constant-Current System arc lamps must be provided with an approved hand switch, also an automatic switch that will shunt the current around the carbons, should they fail to feed properly. The hand switch to be approved, if placed anywhere except on the lamp itself, must comply with requirements for switches on hanger-boards.

Low-Potential Circuit arc lamps must have a cut-out for each lamp or each series of lamps. The branch conductors should have a carrying capacity about fifty per cent in excess of the normal current required by the lamp to provide for heavy current required when lamp is started or when carbons become stuck without overfusing the wires. They must only be furnished with such resistances or regulators as are enclosed in non-combustible material, such resistances being treated as sources of heat. Incandescent lamps must not be used for resistance devices.

Economy coils and compensator coils for arc lamps must be mounted on non-combustible, non-absorptive insulating supports, such as glass or porcelain, allowing an air space of at least one inch between frame and support, and in general to be treated like sources of heat.

INCANDESCENT LAMPS.—The light is produced by a current passing through a continuous refractory conductor, a filament of carbon, enclosed in a hermetically sealed glass bulb from which all the air has been exhausted; the carbon is attached at each end to a piece of platinum which passes through the neck of the bulb and forms a contact point for connection with the conductor; through faulty construction, excessive current, partly burned out carbons, socket in electrical contact, etc., the lamp and socket become very hot and liable to set fire to any inflammable materials in contact with them; hence no lamps must be in contact with tissue paper, cotton batting, cotton, silk or woolen materials (especially blacks and blues), nor should they be in rooms in which there is apt to be any inflammable or explosive gases (unless enclosed in vapor-tight globes), and lamps having any part of their sockets in the electric circuit should be discarded.

Where in series circuit, each lamp must be provided with an automatic cut-out and must be suspended from a hanger-board by means of a rigid tube; under no circumstances can they be attached to gas fixtures and no electro-magnetic device for switches, and no system of multiple-series or series-multiple lighting will be approved.

Low-Potential Systems.—Ordinary flexible cord must not be used for a lamp or lamps of over 3 amperes. Each lamp on flexible cord must be hung on cord from a double pole rosette where ordinary cord is used, but where cord having a heavy slow-burning insulation is used, individual rosettes are not required. In specially dangerous places lamps must be supported from pipe hangers or their equivalent, and keyless sockets used. In damp, wet places where flexible cord and ceiling rosettes cannot be used, lamps may be hung directly from the mains, by two independent wires kept entirely separate, and not smaller than No. 14 B. & S.

Sockets may be of metal or porcelain; if of metal they must be lined with an insulating material which shall absolutely prevent the shell from becoming a part of the circuit even though the wires inside the socket should start from their position under the binding screws. The threaded inlet, when the lamp is not attached to a fixture, must be provided with a strong insulating bushing having a smooth hole, and with the corners rounded and all inside fins removed, so that in no place will the cord be subjected to the cutting or wearing action of a sharp edge.

In rooms where inflammable gases may exist, the socket, as well as the incandescent lamp, must be enclosed in a vapor-tight globe, and in damp or wet places, or over specially inflammable stuff, waterproof sockets must be used; waterproof sockets should be hung by separate stranded rubber-covered wires not smaller than No. 14 B. & S., which should preferably be twisted when the drop is over 3 feet; these wires should be soldered directly to the circuit wires, but supported independently of them.

HANGER-BOARDS.—Hanger-boards must be so constructed that all wires and current-carrying devices thereon shall be exposed to view and thoroughly insulated by being mounted on a non-combustible, non-absorptive insulating substance. All switches attached to the same must be so constructed that they shall be automatic in their action, cutting off both poles to the lamp, not stopping between points when started and preventing an arc between points under all circumstances.

Flexible Cord.—In order that the conductor may be pliable and yet not liable to continual breakage and the dangers of grounds and arcs, this cord is made up of stranded copper conductors not larger than No. 26 or smaller than No. 30 B. & S. gauge, each with an approved insulation, and the group covered with a tough braided outer covering. These cords must not be used where the difference in potential between the two wires is over 300 volts, or as a support for clusters, or in show windows, and must only be used for pendants, wiring of fixtures and portable lamps or motors, and must be so suspended that the entire weight of the socket and lamp will be borne by knots under the bushings in the socket and above the point where the cord comes through the ceiling block or rosette, in order that the strain may be taken from the joints and the binding screws.

The great hazards with flexible cords are, that a strand may be broken and puncture the insulation, and as wires of opposite polarity are so close together, an arc is readily formed and the insulating apt to be burned off, and if a loose end of a strand comes in contact with the socket, etc., a short circuit is caused and heat enough produced to set fire to nearby inflammable materials; through the continual handling of lamps so suspended the danger is greatly increased from the above hazards.

Joints.—A poor joint between wires is productive of much heating by the resistance it offers to the current; this heat at times is sufficient to burn the wire and thus leave a space for an arc to form, hence a poor joint is a dangerous thing. All joints should be made by splicing or joining the wires so as to be mechanically and electrically secure, without solder, and then soldering them to insure preservation; the joints must be covered with an insulation equal to that on the conductors.

Fixture Work.—Where conductors are within or attached to gas fixtures, particular attention must be taken to see that the fixture is thoroughly insulated from all piping or any grounded metal work, by means of approved insulating joints which same must be entirely made of material that will resist the action of illuminating gases, and will not give way or soften under the heat of an ordinary gas flame or leak under a moderate pressure (glass or porcelain is best; hard rubber is apt to soften under action of escaping electricity); joints with soft rubber in their composition must not be used; joints shall be so arranged that a deposit of moisture will not destroy the insulating effect, and shall have an insulating resistance of at least 250,000 ohms between the gas-pipe attachments, and be sufficiently strong to resist the strain they will be liable to be subjected to in being installed. The conductors must be kept free from the grounded part of the pipes, and where shells are used the latter must be constructed in a manner affording sufficient area to allow this requirement. Taps of fixture pipes must be sealed to prevent moisture settling in the pipe on the conductors. When conductors are on the outside of the fixture they must be so secured as not to be abraded by the pressure of the fastenings or motion of the fixture. No combination fixture in which the conductors are concealed in a space less than one-fourth inch between the inside pipe and the outside casing will be approved, and under no circumstances shall there be a difference of potential of more than 300 volts between wires contained in or attached to the same fixture.

CONVERTERS OR TRANSFORMERS.—When an alternating current is produced, it is necessary, before it can be used, to lower the voltage (E. M. F.) and increase the amperage (current). This is done by passing the current through a converter, which consists of a core of thin iron sheets, wound with a fine primary coil of many convolutions and a secondary coil of few convolutions, and all enclosed in a box, which must be a metallic or other non-combustible case; the converter usually transforms a 2,000 or 1,000 voltage down to a 100 or 50 voltage current, but they can be made to lower any number of volts to any given number; on account of their construction and purposes, they are subject to excessive heating, and are consequently highly dangerous.

In central or sub-stations the transformers must be so placed that smoke from the burning out of the coils or the boiling over of the oil (where oil filled cases are used) could do no harm.

Other than at central stations or sub-stations, the transformer should be preferably outside on a pole, or if in the building it must be located at a point as near as possible to that at which the primary wires enter the building and must be placed in an inclosure constructed of fire-resisting material; the inclosure to be used only for this purpose, and to be kept securely locked and access to the same allowed only to responsible persons; the transformer must be effectually insulated from the ground and the inclosure in which they are placed must be practically air-tight, except that it shall be thoroughly ventilated to the outdoor air, if possible, through a chimney or flue. There should be at least six inches air space on all sides of the transformer.

WOODEN MOULDING.—Must have, both outside and inside, at least two coats of waterproof paint, or be impregnated with a moisture repellent, and must be made of two pieces, a backing and capping so constructed as to thoroughly incase the wire, and provide a one-half inch tongue between the conductors, and a solid backing, which under grooves shall not be less than three-eighths of an inch in thickness, and must afford suitable protection from abrasion. It is recommended that only hardwood moulding be used.

ELECTRIC GAS LIGHTING.—Where electric gas lighting is to be used on the same fixture with the electric light no part of the gas piping or fixture shall be in electric connection with the gas-lighting circuit, and the wires used with the fixtures must have a non-inflammable insulation, or, where concealed between the pipe and shell of the fixture, the insulation must be such as required for fixture wiring for the electric light.

The whole installation must test free from the "grounds," and the two installations must test perfectly free from connection with each other.

ELECTRIC HEATERS.—Must, if stationary, be placed in a safe situation, isolated from inflammable materials and be treated as sources of heat. Must each have a cut-out and indicating switch, and have the attachments of feed wires to the heaters in plain sight, easily accessible and protected from interference, accidental or otherwise. The flexible conductors for portable apparatus, such as irons, etc., must have an approved insulating covering, and each heater must be provided with name-plate, giving the maker's name and the normal capacity in volts and amperes.

DECORATIVE SERIES LAMPS.—Incandescent lamps run in series shall not be used for decorative purposes inside of buildings, except by special permission in writing from the Inspection Department having jurisdiction.

TROLLEY WIRES, RAILWAY POWER PLANTS, LIGHTING AND POWER FROM RAILWAY WIRES.—Trolley wires must be no smaller than No. O. B. & S. copper, or No. 4 B & S. silicon bronze, and must readily stand the strain put upon them when in use, must have a double insulation from the ground (in wooden pole construction the pole will be considered as one insulation), and must be capable of being disconnected at the power house, or of being divided into sections, so that in case of fire on the railway route the current may be shut off from the particular section and not interfere with the work of the firemen (this rule also applies to feeders); and they must be safely protected against contact with all other conductors, by separate insulated guard wires directly placed so as to afford full protection from falling or sagging wires.

Railway power plants must be equipped in each feed wire before it leaves the station with an approved automatic circuit-breaker or other device, which will immediately cut off the current in case of an accidental ground. This device must be mounted on a fireproof base, and in full view and reach of the attendant.

Lighting and power from railway wires must not be permitted, under any pretense, in the same circuit with trolley wires with a ground return, except in electric railway cars, electric car houses and their power stations; nor shall the same dynamo be used for both purposes.

Lighting from trolley wires is forbidden because of the danger of introducing into a building a high-potential circuit (often over 500 volts) which has so much capacity back of it and which is thoroughly connected with the earth on one side. Lighting from lower voltage trolley wires is also forbidden on account of the ground connection.

Electric equipment of car houses must have the trolley wires securely supported on insulating hangers. Must have the trolley hangers placed at such distance apart that, in case of a break in the trolley wire, contact cannot be made with the floor. Must have cut-out switch located at a proper place outside of the building, so that all trolley circuits in the building can be cut-out at one point, and line circuit-breakers must be installed, so that when this cut-out switch is open the trolley wire will be dead at all points within 100 feet of the building. The current must be cut out of the building whenever the same is not in use or the road not in operation. Must have all lamps and stationary motors installed in such a way that one main switch can control the whole of each installation—lighting or power—independently of main feeder-switch. No portable incandescent lamps or twin wire allowed, except that portable incandescent lamps may be used in the pits, connections to be made by two approved rubber-covered flexible wires properly protected against mechanical injury; the circuit to be controlled by a switch placed outside of the pit. Must have all wiring and apparatus installed in accordance with rules for constant-potential systems. Must not have any system of feeder distribution centering in the building. Must have the rails bonded at each joint with not less than No. 2 B. & S. annealed copper wire; also a supplementary wire to be run for each track. Must not have cars left with trolley in electrical connection with the trolley wire.

MARINE WORK.—Generators must be located in a dry place, have their frames insulated from their bed-plates, be provided with waterproof covers and be provided with a name-plate giving the maker's name, the capacity in voltage and amperes and normal speed in revolutions per minute.

Wires must be supported in approved moulding or conduit except at switchboard and portables, and no wire must be larger than No. 12 B. & S.; if a greater carrying capacity is required, the wires must be stranded. No single wire smaller than No. 14 B. & S. must be used except in fixture. Stranded wires must be soldered before being fastened under clamps or binding screws, and when they have a conductivity greater than No. 10 B. & S. copper wire they must be soldered into lugs. Splices or taps in conductors must be avoided as far as possible, and all joints must be properly made and covered with waterproof tape and coated or painted with a waterproof compound. For moulding work the wires must have an approved insulating covering, and when passing through water-tight bulkheads and through all decks must have a metallic stuffing tube lined with hard rubber; in case of deck tubes, they shall be boxed near deck to prevent mechanical injury. When passing through beams and non-water-tight bulkheads must be bushed with hard rubber tubing one-eighth of an inch in thickness. For conduit work the wires must have an approved insulating covering, and for unlined conduits must have an additional second outer fibrous covering at least one-thirty-second of an inch in thickness, and sufficiently tenacious to withstand the abrasion of being hauled through the metal conduit; wires must not be drawn into the conduits until the mechanical work on them is finished and the same in place.

Portable conductors must be made of two stranded conductors, each having a carrying capacity equivalent to not less than No. 14 B. & S. wire, and each covered with an approved insulation and covering. Where not exposed to moisture or severe mechanical injury, each stranded conductor must have a solid insulation at least one-thirty-second of an inch in thickness, and must show an insulation resistance between conductors, and between either conductor and the ground, of at least one megohm per mile after one week's submersion in water at seventy degrees Fahrenheit and after three minutes' electrification, with 500 volts, and be protected by a slow-burning, tough-braided outer covering. Where exposed to moisture and mechanical injury—as for use on decks, holds and fire rooms—each stranded conductor shall have a solid insulation, to be approved, of at least one-thirty-second of an inch in thickness and protected by a tough braid. The two conductors shall then be stranded together, using a jute filling. The whole shall then be covered with a layer of flax, either woven or braided, at least one thirty-second of an inch in thickness, and treated with a non-inflammable, waterproof compound. After one week's submersion in water at seventy degrees Fahrenheit, at 550 volts and a three minutes' electrification, must show an insulation between the two conductors, or between either conductor and the ground, of one megohm per mile.

Bell or other wires shall never be run in the same duct with lighting or power wires.

TABLE OF CAPACITY OF WIRES.

B. & S. G.	Area Actual C. M.	No. of Strands.	Size of Strands B. & S. G.	Amperes.
19	1,288	..	..	..
18	1,624	..	..	3
17	2,048	..	..	..
16	2,583	..	..	6
15	3,257	..	..	..
14	4,107	..	..	12
12	6,530	..	..	17
..	9,016	7	19	21
..	11,368	7	18	25
..	14,336	7	17	30
..	18,081	7	16	35
..	22,799	7	15	40
..	30,856	19	18	50
..	38,912	19	17	60
..	49,077	19	16	70
..	60,088	37	18	85
..	75,776	37	17	100
..	99,064	61	18	120
..	124,928	61	17	145
..	157,563	61	16	170
..	198,677	61	15	200
..	250,527	61	14	235
..	296,387	91	15	270
..	373,737	91	14	320
..	413,639	127	15	340

When greater conducting area than that of 19 B. & S. G. is required, the conductor shall be stranded in a series of 7, 19, 37, 61, 91 or 127 wires, as may be required; the strand consisting of one central wire, the remainder laid around it concentrically, each layer to be twisted in the opposite direction from the preceding.

Switchboards must be made of non-combustible, non-absorptive insulating material, such as slate or marble, must be kept free from moisture, be located so as to be accessible from all sides, have a main switch, main cut-out and ammeter for each generator, also a voltmeter and ground detector, and a cut-out and switch for each side of each circuit leading from the board.

Resistance boxes must be made of non-combustible material in such a way as to allow sufficient ventilation for the uses to which they are put, and should preferably be located on the switchboard, but when not on the board, must be mounted on non-inflammable, non-absorptive insulating material.

Switches must have non-combustible, non-absorptive insulating bases, must be double-pole when circuit which they control supplies more than six sixteen-candle-power lamps or their equivalent, and when exposed to dampness they must be enclosed in a water-tight case. When located on the switchboard they must be of the knife pattern. Each freight compartment must be separately controlled by a switch.

Cut-outs with proper non-combustible, non-absorptive bases must be placed at every point where a change is made in the size of the wire (unless the cut-out in the larger wire will protect the smaller wire), and in such places as upper decks, holds, cargo spaces and fire rooms a water-tight and fireproof cut-out may be used, connecting directly to mains when such cut-outs supply circuits requiring not more than 600 watts energy; when placed anywhere except on switchboards and certain places, as cargo spaces, holds, fire rooms, etc., where it is impossible to run from center of distribution, they shall be in a cabinet lined with fire resisting material. A single-pole covered cut-out may be placed in the moulding when same contains conductor supplying circuits requiring not more than 220 watts energy. Except for motors, searchlights and diving lamps shall be so placed that no group of lamps, requiring a current of more than six amperes, shall ultimately dependent upon one cut-out.

Fixtures shall be mounted on blocks made from well-seasoned lumber treated with two coats of white lead or shellac, and shall be wired with same grade of insulation as portable conductors which are not exposed to moisture or mechanical injury. Ceiling fixtures over 2 feet in length must be provided with stay chains.

Lamps on fixtures, where exposed to dampness, must be surrounded by vaporproof globes, and when exposed to mechanical injury, must be surrounded by globes protected by stout wire guards.

Sockets.—No portion of the lamp socket or lamp base exposed to contact with outside objects shall be allowed to come into electrical contact with either of the conductors.

Wooden mouldings must be made of two pieces, a backing and a capping, so constructed as to thoroughly incase the wire and provide a one-half-inch tongue between the conductors, and a solid backing which, under grooves, shall not be less than three-eighths of an inch in thickness; must be of well-seasoned lumber, and be treated inside and out with at least two coats of white lead or shellac. Where moulding is run over rivets, beams, etc., a backing strip must first be put up and the moulding secured to this. Capping must be secured by brass screws.

Interior conduits must be equipped at every outlet with an approved outlet box; must be continuous from one junction box to another, or to fixtures, and the conduit must properly enter all fittings. Conduits must be installed as complete systems without the conductors.

Signal lights must be provided with approved tell-tale board, located preferably in pilot-house, which will immediately indicate a burned-out lamp.

Motors must be thoroughly insulated. Where possible, should be set on base frames made from filled, hard, dry wood and raised above surrounding deck. On hoists and winches they shall be insulated from bed-plates by hard rubber, fiber or similar insulating materials. Shall be covered with a waterproof cover when not in use. Must each be provided with a name-plate giving maker's name, the capacity in volts and amperes and the normal speed in revolutions per minute. Must be wired under the same precautions as with a current of same volume and potential for lighting. The motor and resistance box must be protected by a double-pole cut-out and controlled by a double-pole switch, except in cases where one-quarter horse-power or less is used.

The leads or branch circuits should be designed to carry a current at least fifty per cent greater than that required by the rated

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capacity of the motor to provide for the inevitable overloading of the motor at times.

Insulation Resistance.—The wiring in any vessel must test free from grounds; *i. e.*, the complete installation must have an insulation between conductors and between all conductors and the ground (not including attachments, sockets, receptacles, etc.) of not less than the following:

Up to	25	amperes	800,000	ohms.
"	50	"	400,000	"
"	100	"	200,000	"
"	200	"	100,000	"
"	400	"	25,000	"
"	800	"	25,000	"
"	1,600	"	12,500	"

All cut-outs and safety devices in place in the above.

Where lamp sockets, receptacles and electroliers, etc., are connected, one-half of the above will be required.

SIGNALING SYSTEMS (governing wiring for telephone, telegraph, district messenger and call-bell circuits, fire and burglar alarms, and all similar systems).—Outside wires should be run in underground ducts or strung on poles and, as far as possible, kept off of buildings, and must not be placed on the same cross-arm with electric light or power wires. When outside wires are run on same pole with electric light or power wires, the distance between the two inside pins of each cross-arm must not be less than twenty-six inches. All aerial conductors and underground conductors which are directly connected to aerial wires must be provided with some approved protective device, which shall be located as near their point of entrance to the building as possible, and not less than six inches from curtains or other inflammable material. If the protector is placed inside of building, wires, from outside support to binding-posts of protector, shall comply with the following requirements:

1. Must be of copper, and not smaller than No. 16 B. & S. gauge.
2. Must have an approved rubber insulating covering (see No. 41).
3. Must have drip loops in each wire immediately outside the building.
4. Must enter buildings through separate holes sloping upward from the outside; when practicable, holes to be bushed with non-absorptive, non-combustible insulating tubes extending through

their entire length. Where tubing is not practicable, the wires shall be wrapped with two layers of insulating tape.

5. Must be supported on porcelain insulators, so that they will not come in contact with anything other than their designed supports.

6. A separation between wires of at least two and one-half inches must be maintained.

In case of crosses these wires may become a part of a high-voltage circuit, so that similar care to that given high-voltage circuits is needed in placing them. Reliable porcelain bushings at the entrance holes are desirable, and are only waived under adverse conditions, because the state of the art in this type of wiring makes an absolute requirement inadvisable. The ground wire of the protective device shall be run in accordance with the following requirements:

1. Shall be of copper, and not smaller than No. 16 B. & S.

2. Must have an approved rubber insulating covering (see No. 41).

3. Shall run in as straight a line as possible to a good, permanent ground, to be made by connecting to water or gas pipe, preferably water pipe. If gas pipe is used, the connection, in all cases, must be made between the meter and service pipes. In the absence of other good ground, the ground shall be made by means of a metallic plate or bunch of wires buried in permanently moist earth.

In attaching a ground wire to a pipe, it is often difficult to make a thoroughly reliable solder joint. It is better, therefore, where possible, to carefully solder the wire to a brass plug, which may then be firmly screwed into a pipe fitting. Where such joints are made under ground they should be thoroughly painted and taped to prevent corrosion. The protector to be approved must comply with the following requirements:

1. Must be mounted on non-combustible, non-absorptive insulating bases, so designed that when the protector is in place, all parts which may be alive will be thoroughly insulated from the wall holding the protector.

2. Must have the following parts:

A lightning arrester which will operate with a difference of potential between wires of not over 500 volts, and so arranged that the chance of accidental grounding is reduced to a minimum.

A fuse designed to open the circuit in case the wires become crossed with light or power circuits. The fuse must be able to open the circuit without arcing or serious flashing when crossed with any ordinary commercial light or power circuit.

A heat coil, if the sensitiveness of the instrument demands it, which will operate before a sneak current can damage the instrument the protector is guarding.

Heat coils are necessary in all circuits normally closed through magnet windings, which cannot indefinitely carry a current of at least 5 amperes.

The heat coil is designed to warm up and melt out with a current large enough to endanger the instruments if continued for a long time, but so small that it would not blow the fuses ordinarily found necessary for such instruments. These smaller currents are often called "sneak" currents.

3. The fuses must be so placed as to protect the arrester and heat coils, and the protector terminals must be plainly marked "line," "instrument," "ground."

Wires beyond the protector, except where bunched, must be neatly arranged and securely fastened in place in a convenient, workmanlike manner. They must not come nearer than six inches to any electric light or power wire in the building unless incased in approved tubing so secured as to prevent its slipping out of place.

The wires would ordinarily be insulated, but the kind of insulation is not specified, as the protector is relied upon to stop all dangerous currents. Porcelain tubing or circular loom conduit may be used for incasing wires where required as above.

Wires connected with outside circuits, where bunched together within any building, or inside wires, where laid in conduits or ducts with electric light or power wires, must have fire-resisting coverings, or else must be enclosed in an air-tight tube or duct.

It is feared that if a burnable insulation were used, a chance spark might ignite it and cause a serious fire, for many installations contain a large amount of very readily burnable matter.

NOTES.—General Suggestions (National Board of Fire Underwriters). In all electric work conductors, however well insulated, should always be treated as bare, to the end that under no conditions, existing or likely to exist, can a grounding or short circuit occur, and so that all leakage from conductor to conductor, or between conductor and ground, may be reduced to the minimum.

In all wiring special attention must be paid to the mechanical execution of the work. Careful and neat running, connecting, soldering, taping of conductors and securing and attaching of fittings, are specially conducive to security and efficiency, and will be strongly insisted on.

In laying out an installation, except for constant-current systems, the work should, if possible, be started from a center of distribution, and the switches and cut-outs, controlling and connected with the several branches, be grouped together in a safe and easily accessible place, where they can be readily got at for attention or repairs. The load should be divided as evenly as possible among the branches, and all complicated and unnecessary wiring avoided.

The use of wire-ways for rendering concealed wiring permanently accessible is most heartily endorsed and recommended; and this method of accessible concealed construction is advised for general use.

Architects are urged, when drawing plans and specifications, to make provision for the channeling and pocketing of buildings for electric light or power wires, and in specifications for electric gas lighting to require a two-wire circuit, whether the building is to be wired for electric lighting or not, so that no part of the gas fixtures or gas piping be allowed to be used for the gas-lighting circuit.

Insulation Resistance (National Board of Fire Underwriters).—The wiring in any building must test free from grounds; *i. e.*, the complete installation must have an insulation between conductors and between all conductors and the ground (not including attachments, sockets, receptacles, etc.,) of not less than the following:

Up to	5	amperes	4,000,000	ohms.
"	10	"	2,000,000	"
"	25	"	800,000	"
"	50	"	400,000	"
"	100	"	200,000	"
"	200	"	100,000	"
"	400	"	25,000	"
"	800	"	25,000	"
"	1,600	"	12,500	"

All cut-outs and safety devices in place in the above.

Where lamp sockets, receptacles and electroliers, etc., are connected, one-half of the above will be required.

Soldering Fluid (National Board of Fire Underwriters).—The following formula for soldering fluid is suggested.

Saturated solution of zinc chloride	5 parts.
Alcohol	4 parts.
Glycerine	1 part.

Too much care cannot be taken in making joints; a defective joint, although it may not for a time so far lower the insulation as to cause a serious leakage of current, is almost certain to go completely bad sooner or later. (The Elec. Engineer's Pocket Book—Kempe).

ELECTRICAL UNITS.

UNIT.	NAME.	DERIVATION.	DEFINITION.
Electromotive Force E. M. F.	Volt	Ampere × Ohm	Pressure analogous to the head of water in hydraulics.
Resistance R.	Ohm	Volt + Ampere	Ohm's law states that the current in any circuit is equal to the E. M. F. acting on it divided by its resistance.
Current C.	Ampere	Volt + Ohm	The flow of electricity produced by the pressure of one volt on a resistance of one ohm.
Quantity Q.	Coulomb.	Ampere + Second.	The amount of electricity which flows past a given point in one second on a circuit conveying one ampere.
Capacity K.	Farad	Coulomb + Volt	A condenser which will hold one coulomb at a pressure of one volt has a capacity of one farad.
Power P.	Watt	Ampere × Volts	$\frac{1}{746}$ of a horse power.

Relations Between Electrical and Mechanical Units.—The product of the amperes (current) multiplied by the volts (E. M. F.) and divided by 746 is equivalent to the horse-power developed.

Arc Electrical Lamp.—A 2,000 candle-power "full arc" lamp takes 9.6 amperes, while a "half arc" lamp of 1,200 candle-power takes 6.8 amperes. Arc lamps are usually run at 50 volts. The top or positive carbon burns about 1½ inches per hour, and twice as fast as the lower or negative carbon.

Grounds.—The contact through the earth of both sides of a circuit; this may be produced by escape of current down wet walls, pipes, through trees and other ways.

Incandescent Electric Lamps.—A 16-candle-power lamp is usually run at a potential of 100 volts and takes about five-tenths amperes; when the lamp is hot it has a resistance of about 168 ohms, hence it takes (E. M. F. ÷ R. = C., that is 100 ÷ 168 = 0.595) about six-tenths amperes to run it.

A 1,000-candle-power arc lamp is usually run at a potential of 50 volts, and takes about 10 amperes.

One indicated horse-power will run 8 incandescent lamps of 16-candle-power, or one arc lamp of 1,000 candle-power.

Kinks, Turns, Knots, etc., in wires should be avoided, as they tend to produce overheating by the resistance they offer to the current.

Short Circuit.—A connection between two parts of a circuit, which connection is of low resistance compared to the intercepted portion. A short circuit can be produced by poorly insulated wires against a wet surface, by wires being in contact with metal, by placing poorly insulated wires close together, in flexible cords, etc.

Tubes for wires running through walls and partitions should slope toward the side of the wall or partition on which the greatest amount of moisture is apt to be.

Care of Apparatus.—As electric light and power apparatus is subject to derangement at all points, and in the great majority of cases, derangements are of the character that can produce fire or serious damage to the apparatus, it is highly necessary, that in plants having more than one dynamo, or in which the installation is large, that there should be in constant attendance, while the dynamos are running, a competent experienced attendant.

No alterations or extensions of systems should be made by any one other than an expert.

DEFINITIONS—Circuit.—Included in this are all of the wires and apparatus which form the path for the electric current from and to the generating device, and including the generating device.

Circuit Breaker.—Any appliance or apparatus which will open and close a circuit, hence a switch, a fuse block, a cut-out, etc. While a switch is in fact a circuit breaker it is not commercially termed so, nor is it treated so. Circuit breakers must have non-combustible, non-absorptive bases, with similar covers (when not in approved cabinets); in the construction of the breaker there is a fusible strip or wire of metal which melts upon the over increase of the current, and hence prevents the passing of the current. The object of placing these devices in a circuit is to prevent the overloading of the circuit with electricity.

Closed Circuit.—One in which the current is continuous throughout. By opening a switch or any other device in the circuit, the circuit becomes an open circuit.

Currents, Alternating.—A succession of currents in which there are two directions of flow, *i. e.,* opposite directions, and in which succeeding currents are of short duration, and in opposite directions. Constant.—An unvarying current. "In electric series, incandescent lighting, a constant current is employed and the system is termed as above. In arc lighting systems the constant current series arrangement is almost universal."—(Standard Electrical Dictionary.) Multiphase, Polyphase, Rotary.—Currents produced on a single generator, alternating in a constant proportion of periods.

Electrolysis.—The decomposition of a compound into its elements or its constituents by the action of electricity. The electrolysis of water pipes underground on the line of a trolley line is caused by the return currents acting upon the pipe and "eating it away," or decomposing it.

Potential, Constant.—In which the potential is unchanging. "The ordinary system of incandescent lighting is a constant potential system, an unvarying potential difference being maintained between the two leads, and the current varying according to requirements."—(Standard Electrical Dictionary.)

"Potential in electricity is analogous to temperature; and as heat tends to pass from a point at a higher to one at a lower temperature, so electricity tends to move from a higher to a lower potential."—(Century Dictionary.)

"Bushings must be long enough to bush the entire length of the hole in one continuous piece, or else the hole must first be bushed by a continuous waterproof tube, which may be a conductor, such as iron pipe; the tube then is to have a non-conducting bushing pushed in at each end so as to keep the wire absolutely out of contact with the conducting pipe."—(National Board of Fire Underwriters.)

CHAPTER VII.

AUTOMATIC SPRINKLER EQUIPMENT

(All rulings in this chapter are as per rules and requirements of the National Board of Fire Underwriters for the installation of automatic sprinkler equipments, 1901.)

Among all the devices for extinguishing fires in their incipiency, none is so efficient at all times as the automatic sprinkler, for all other apparatus needs the agency cf a person or persons to be of service, whereas this device, being automatically set in action by the agency of heat alone, is always ready for action without any human help.

An automatic sprinkler head is a valve with a seat held in place by fusible solder, and having a deflector for distributing the water in an umbrella-shaped spray evenly over a surface beneath it of 10 feet, more or less, square. The solder melts at temperatures varying from 165 degs. F. to 360 degs. F., the degree of heat being in accordance with the amount of heat normally in a room; hence in a dry room the degree of the fusing point would be much higher than that in a mercantile risk. The heads are attached to lines of pipe located close to the ceiling, usually from 8 to 11 feet apart, the heads being from 8 to 10 feet apart on the pipes. Water is fed to the pipes from a tank, pump, public water supply, or any other adequate supply. Upon the melting of the solder, the valve seat is released, the valve opened. and the water thrown about by the distributor.

There are two systems of automatic sprinklers; the wet system, in which water continually stands in the pipes, for use in buildings in which there is always enough heat to prevent water freezing in the pipes; and the dry system, in which the pipes are filed with air as far back as an automatice valve which is held closed against the pressure of the water by the pressure of the air, and which is located at a point beyond which provision is made against the possibility of the water in the pipe freezing, for use in buildings in which from absence of heat there is a probability of water in pipes freezing.

The following risks especially should be thoroughly equipped with automatic sprinklers: Agricultural implement works, bakeries, boot and shoe factories, candy factories, carriage factories, chair factories, cigarette factories, cotton compresses, cotton mills, cotton seed oil mills, cotton (raw) warehouses, distilleries, flour mills, furniture factories, linseed oil mills, oil cloth works, paint factories, piano factories, power printers and lithographers, rubber works, sash, door and blind factories, saw and planing mills, snuff factories, stamping and tin ware factories, starch works, tanneries, bark mills, wholesale druggists, and all parts of stage section of theaters.

Strongly advised in all manufacturing buildings.

Advised in all buildings.

Before a building is sprinkled, all the needless ceiling, sheathing, hollow siding, tops of high shelves, needless partitions or decks should be removed. Vertical drafts through buildings (such as elevator-ways, well-holes, dummy-ways, chutes, etc.), are detrimental to the proper action of sprinklers and must be "stopped" where practicable.

A maximum protection must not be expected where sprinklers are at more or less permanent disadvantage, as in the case of stocks very susceptible to smoke and water damage, buildings having deep piles of hollow goods, excessive drafts, explosion hazards, or large amounts of benzine or similar fluid.

DISTRIBUTION OF HEADS.—Equipments should thoroughly cover all parts, including all concealed spaces, closets, under and in stairways, blind attics, basements, rope-drives, beltways, pipe, gear and pulley boxes, drying and heating boxes, tenter and dry rooms' inclosures, conveyor trunks, waste picker-discharge closets, elevator-ways, skylights, shafts, lofts, chutes, under decks, platforms and half-floors, etc. "Experience teaches that sprinklers are often necessary where seemingly least needed; their protection is required not alone where a fire may begin, but also wherever any fire may extend, including wet and damp locations."

Location of Heads.—To be placed in an upright position wherever possible, and always so on a dry-pipe system, with the deflector parallel to the ceiling, roof, or the incline of stairs, but when in the peak of a pitched roof, they shall be horizontal. In vertical shafts having inflammable sides, a sprinkler to be provided within shaft for each 200 square feet of the inflammable surface; such sprinklers to be installed at each floor when practicable and always when shaft is trapped; shafts lined with metal or wood lath and plaster are construed as inflammable.

There should be at least one head for each 100 superficial feet of surface protected, with extra heads so placed as to cover all spaces where heads regularly placed will not fully protect.

In "Mill" constructed buildings, 6-foot to 12-foot bays, each bay should have at least one line of heads place in its center, and distance between sprinklers on each line must not exceed 8 feet in 12-foot bays, 9 feet in 11-foot bays, 10 feet in 6 to 10-foot bays.

In open joisted construction, where lines run parallel with the joists, heads on lines should not be over 10 feet apart, and where lines are at right angles with joists, the heads should not be over 8 feet apart.

Exception.—An exception may be made to this rule if the conditions warrant, viz., special permission may be given to install but one line of sprinklers in bays 10 to 11½ feet wide from center to center of the timbers, which support the joists. In all cases where such bays are over 11½ feet wide, two or more lines of sprinklers must be installed in each bay as required by the rules for spacing. This does not apply where beams are flush with the joists.

The distance from wall or partition shall not exceed one-half the distance between heads in the same direction. A line of sprinklers should be run on each side of a partition; the cutting of holes through a partition to allow sprinklers on one side to distribute on the other side is not advocated, as it is found to be inadequate; this applies to both slatted and solid partitions.

Under a pitched roof, sloping more steeply than 1 foot in 4, one line of sprinklers to be located in peak of roof, and sprinklers on either side to be spaced according to above requirements. Distance between sprinklers to be measured on a line parallel with roof.

Under open finish joisted construction floors, decks and roofs.

the sprinklers shall be "staggered," spaced so that heads will be opposite a point half way between sprinklers on adjacent lines, the end heads on alternate lines to be within 3 feet from sides of room.

This regulation applies to all sprinklers under open finished joists, not excepting the sprinklers within a bay whether on one, two, or more lines; where the joists are flush with the timbers, or where the channel ways between joists are "stopped" at intervals. Care must be taken that the end and intermediate sprinklers do not violate the rules for joist work spacing.

Sprinklers to be so staggered as to distribute water into opposite joist channel ways.

The deflector of a sprinkler head must be at least 3 inches, and not over 10 inches from ceiling or bottom of joists. Where two (2) or more floors communicate by openings not provided with approved "stops," acceptable "curtain boards" must be fitted around the openings at each floor, or, by consent of underwriters having jurisdiction, the automatic sprinklers at each floor may be placed within one (1) foot of the openings.

Special instructions must be received from underwriters having jurisdiction relative to location of sprinklers under floors and roofs of unusual construction which would interfere with distribution of water and for which provision is not hereinbefore made.

PIPE SIZES—General Schedule.—In no case shall the number of sprinklers on a given size pipe exceed the following:

Size of Pipe.	Maximum No of Sprinklers Allowed
¾ inch	1 sprinkler
1 "	2 "
1¼ "	4 "
1½ "	8 "
2 "	16 "
2½ "	28 "
3 "	48 "
3½ "	78 "
4 "	110 "
5 "	150 "
6 "	200 "

Branch Line Schedule.—If more than 6 sprinklers be placed on a "branch line" of pipe, the following schedule shall apply:

Size of Pipe.	Maximum No. of Sprinklers Allowed.
¾ inch	1 sprinkler
1 "	2 "
1¼ "	4 "
1½ "	6 "
2 "	8 "
2½ "	16 "
3 "	28 "

Furthermore, no feeder to any such "branch line" shall be smaller than said "branch line."

The old-fashioned "Parmelee" or "tree" arrangement of piping, viz., a pipe with short branches to one sprinkler on either side, shall be construed as coming under this rule.

PIPING—Location of Feed Pipe.—"Center central" or "side central" feed to sprinklers is recommended. The former is preferred, especially where there are over 6 sprinklers on a branch line. End feed is not approved. Pipings and fittings should be of the best quality and carefully erected. To lessen friction to the greatest possible extent, long-bend fittings should be used on all the larger sized pipes, and all pipes should be as free as possible of unions, couplings, reducers, etc.

There should be a separate riser in each building and in each section of a building divided by fire walls. The size of each riser to be sufficient to supply all the sprinklers on any one floor, as determined by the standard schedule of pipe sizes. If the conditions warrant, special permission will be granted allowing the sprinklers in a fire section of small area (total number of sprinklers not to exceed 48 per floor) to be fed from the riser in another section.

Where there are sprinklers enough in one room to require a 6-inch riser, according to schedule, it is preferable to have these sprinklers supplied through two (2) or more smaller risers.

In order to obtain thorough drainage of all the piping, all pipes should have such a pitch that all of the water in them will flow back into the risers, or should be connected with auxiliary pipes for draining. Drain pipes, not smaller than 2 inches, must be at the base of each riser, and where there is a cut-off valve on each floor, in each supply pipe for each floor on each floor; drain pipes to be taken off immediately above the cut-off valves. Each drain pipe to have a valve, which same must be kept strapped on sealed shut.

The connections between all supplies should be between all risers or dry pipe valves and the supplies.

In systems with two or more water supplies the connections between the supplies should be under ground.

Main supply pipes to systems should, as far as possible, be under ground. Connections between any two or more risers should be at their bases.

All underground piping must be of cast iron (guaranteed to withstand a pressure of 300 pounds), excepting the piping between any air valve and the riser or risers it runs to, this piping being of wrought iron.

All exposed pipes must be supported on well secured metal hangers or standards.

Test pipes not less than ½ inch in diameter, connected with upper lines of sprinkler pipes, and arranged to discharge outside of the building should be placed on each system.

In single spaces where the area requires more than 150 heads there should be at least two supply pipes.

VALVES.—There shall be a straightway gate valve and a straightway check valve in the pipe connecting each water supply with the sprinkler system. Straightway check valves to be placed in horizontal pipe, or in vertical pipe "looking up," never "looking down."

Place the gate valve called for in each controlling pipe, close to the supply, as at the tank, pump, or in the pipe connecting the riser to the water works system.

Main discharge pipes from gravity and pressure tanks, as well as from water works systems and pumps to connect with sprinkler system at foot of riser. Locate in this lower level the check valve in each connecting pipe, also one gate valve controlling all water supply to sprinklers.

Where sprinklers are supplied from yard main, place, if possible, an outside post indicator gate valve in connecting pipe at safe distance from building (say 40 feet). Cases about post gate valves to be arranged to drain through at least ¾-inch outlet having a non-corrosive bushing.

All gate valves (unless they are fitted with post indicators) in supply pipes to sprinklers, in discharge pipes from tanks, or in suction and discharge pipes from pumps to be of outside screw and yoke or approved indicator pattern, and to be kept secured open with padlocked or riveted leather straps passing around the riser and spoke of the wheel. Draw-off valves to be secured closed.

When a pump, not located in a non-combustible pump house, discharges into a yard main fed by another supply, a check valve or post gate valve shall be placed in this discharge pipe outside the building, under ground.

Each under ground check valve to be located in a pit accessible through a man-hole. Pit to be tight enough to keep out water from the ground or surface and to be provided with a deck, forming a double air space, to prevent freezing.

WET PIPE SYSTEMS.—Preference is given to this class of sprinkling. If necessary, in order to maintain a wet pipe system, extra heat should be provided, in preference to making the system dry pipe.

DRY PIPE SYSTEMS.—Where it is impossible to provide against a liability to freezing by supplying heat in a building, the dry pipe system is necessary. Dry pipe systems should be constant throughout the year. A dry pipe system is not recommended where a wet pipe system can be used.

Especial care must be taken to arrange all sprinkler pipes and fittings so that they may be thoroughly drained. Sprinklers must be located in an upright position.

Large dry pipe systems to be provided with "drum drips" preferably located in warm places, at discretion of the underwriters having jurisdiction.

All water supplies to sprinklers must enter system below dry valve.

A large number of sprinklers (500 or more) on a dry system to be supplied through two or more dry valves. System to be divided horizontally.

There shall be an independent pipe from air pump to each air system. Locate in each pipe a gate valve, check valve and pressure gauge.

Where exposed to cold, the dry pipe valve to be located in an approved underground pit or inclosed in a closet of sufficient size to give 2½ feet free space on all sides of and above and below the valve. Make double walled top, sides and bottom with four (4) inch hollow space. Space may be filled with tan bark, mineral wool, etc., as desired. Heat by steam. lard oil lantern, or gas. Provide a wet pipe sprinkler in closet with shut-off valve.

It is advisable that a steam driven air pump be used instead of a power pump.

If it is necessary to have but fifty (50) per cent or less of the total number of sprinklers on an air system, only such sprinklers should be thus pipe; the remainder to be on wet system.

This rule requires small dry pipe systems for show windows, blind attics or other minor portions exposed to freezing.

AUTOMATIC ALARMS.—Every automatic sprinkler system should contain an alarm valve so constructed that a flow of water through same will operate an electric gong, a mechanical gong, or both, as the character of the property and circumstances may require. In cities where there is an alarm company with a central station, the alarm valve may be connected with such central station. In other places, especially in small towns, the valve may be directly connected with public fire department house or some other suitable place.

The use of both electric and mechanical gongs is strongly recommended. The gong of the latter type can be located on the outside of building or any other desirable place on the premises.

The bell must be not less than 6 inches in diameter. Where there is only one outside connection, bell shall be of vibrator pattern. Where there are two outside connections, bells to be wired in series, a vibrator being placed in principal one and a single stroke in the other.

System to be tested daily by closing a circuit through the binding posts of the alarm valve. Test to be recorded by a device which shall make a series of punctures on a dial showing the vibration of the main bell. This device to be of single stroke pattern nominally out of main circuit (that is in the test circuit connecting the binding posts) in series with and vibrated by main bell.

Switches for cutting out alarms are prohibited.

WATER SUPPLY.—Two independent supplies are absolutely essential to the best equipment. At least one of the supplies to be automatic and one to be capable of furnishing water under heavy pressure. The following are acceptable supplies: Public water works system, duplex steam pump, private reservoir or stand-pipe, gravity tank, air pressure tank and rotary pump. No water supply for sprinklers to pass through a meter or pressure regulating valve, except by special consent.

Connection from water supply or main pipe system to sprinkler riser to be equal to or larger in size than the riser, and to supply no hydrant or stand-pipe.

Public Water Works System (rules also applicable to private reservoir and stand-pipe systems) should give not less than 25 pounds static pressure at all hours of the day at highest line of sprinklers. Street main should be of ample size, in no case less than 6 inches. If possible avoid a dead end in street main by arranging main to be fed at both ends.

Steam Pump to be of approved duplex type, Underwriter pattern preferred, and never of less capacity than 500 gallons per minute. (See Chapter VIII.)

Gravity Tank of a minimum capacity of 5000 gallons, properly supported and built, must be placed at a proper elevation, the greater the elevation the less likelihood of inefficient service; the National Board of Fire Underwriters' rules do not specify any given elevation, but an elevation of at least 10 feet in dry goods and similar hazards, and 15 feet in woodworkers, textile mills and similar hazards is generally asked for. Provision must be made to prevent water from freezing in tank and pipes communicating with it. A tank exposed to the weather must have a double cover provided with a trap-door. When a steam pipe is run to the tank, it should be run directly from the boiler and have a controlling valve located in the boiler room; proper method should be provided to prevent siphoning in this pipe.

Tank to be provided with a water level indicating device of a satisfactory character, and provisions made for the draining of the tank independently of the sprinkler system.

Tank to be used as a supply to automatic sprinkler system only, except that, at the discretion of the underwriters, tank may be made larger than called for, and so arranged that the excess supply only may be used for domestic service. (This, however, is not recommended on account of the increase of sediment produced in the tank from the extra quantity of water passing through.)

Water for filling tank shall be conveyed through fixed iron piping not less than 1¼ inches in size. Sprinkler piping not to be used for this purpose.

End of discharge pipe to sprinkler system should enter bottom of tank and project above bottom 4 inches, to avoid sediment entering pipe system.

A permanent substantial ladder extending 3 feet above tank or satisfactory stairway must be maintained to allow access to tank on outside. Also a ladder to be permanently located inside tank. The outside ladder at a tank exposed to the weather affords a treacherous foothold at best. For years after it is erected, it must be used by inspectors in all seasons and conditions of wind, temperature and storm. A ladder of much more than ordinary strength and durability is required and must be most securely attached. A heavy iron pipe ladder, having diamond-shaped treads, is recommended.

Pressure tank to be of a minimum capacity of 4500 gallons, not to be located below the upper story of building, to be properly built and supported, to be provided with a water gauge (the two valves in the water gauge are ordinarily to be kept closed, and opened only to ascertain the amount of water in tank, as breakage of or leakage about glass would cause the escape of pressure), and a drain so that the tank can be emptied independently of the sprinkler system.

Tank to be used as a supply to automatic sprinkler and hand hose only. Tank to be kept two-thirds full of water, and an air pressure (not less than 75 pounds) maintained, such as will give not less than 15 pounds pressure on highest line of sprinklers when all water has been discharged from tank.

Water for supplying tank to be conveyed through fixed iron piping not less than 1¼ inches in size. Sprinkler piping not to be used for this purpose. Pipe from air pump to tank to be not smaller than ¾ inch; to be independent of water supply pipe; to connect with tank above the water level. Both water and air connections to be fitted with check and stop valves located near tank. It is desirable to have water fed to tank by a pump so that proper water level may be restored at any time without reducing air pressure.

Wherever steam is available, a steam driven air compressor shall be used.

Rotary Pump to be of an approved type and have a rated capacity of not less than 590 gallons per minutes, and to have gears at both ends. (See Chapter IX.)

Steamer Connections.—In addition to the above required double supply, it is recommended that a hose inlet pipe to sprinkler system be provided for connection from hose or steamer of public fire department, in all cases when the public water works is not sufficient to exert 25 pounds pressure at highest sprinkler, or is not connected with the sprinklers.

The pipe to be not less than 3 inches in diameter, fitted with a straightway check valve (but not with a gate valve), to be attached above dry or gate valve controlling sprinkler riser where there is but one riser and below said dry or gate valve where the equipment has more than one riser.

Hose connection to suit thread of public department. Large buildings to have several such connections designated by proper signs.

UNDERGROUND PIPES AND FITTINGS.—See Chapter XI.

OPEN SPRINKLERS.—See Chapter XI.

MISCELLANEOUS RULES—(National Board of Fire Underwriters).—Circulation of water in sprinkler pipes is very objectionable, owing to greatly increased corrosion, deposit of sediment and condensation drip from pipes; sprinkler pipes must not be used in any way for domestic service.

Hand hose, to be used for fire purposes only, may be attached to sprinkler pipes within a room under the following restrictions:

Hose not to be larger than 1¼-inch.

Nozzle not to be larger than ½-inch.

Hose not to be connected to any sprinkler pipe smaller than 2½ inches and never to be attached to a dry pipe system.

CAUTIONS AND PROHIBITIONS (National Board of Fire Underwriters).—Where pipes are painted or bronzed for appearance, the moving parts of sprinkler heads must not be so coated.

Sprinkler heads must be free to form an unbroken spray blanket for at least 2 feet under the ceiling from sprinkler to sprinkler and sides of room. Any stock piles, racks, or other obstructions interfering with such action are not permissible. Where a building settle and deprives a dry pipe system of its drainage, the drainage should be restored by shortening the vertical piping.

Sprinkler piping must not be used for the support of stock, clothing, etc. It is not permitted to change, plug up or remove the fittings pertaining to dry pipe valves, pressure tanks, pumps, gauges, etc. If such fittings leak or become deranged, they are to be put in order. There should be maintained on the premises a supply of extra sprinklers (never less than six) to promptly replace any fused by fire or in any way injured.

The Automatic Sprinkler (National Board of Fire Underwriters).—The following rules for the construction of an automatic sprinkler head are but a partial outline of requirements. An automatic sprinkler which will meet these requirements and no more will by no means be necessarily acceptable:

1. Discharge Capacity.—As a basis for these rules, it is required that each automatic sprinkler have an unobstructed outlet of such size and form that with 5 pounds pressure maintained at the sprinkler, it will discharge approximately 12 gallons per minute.

2. Pressure Test.—An automatic sprinkler upon original test must not leak at or under a pressure of 300 pounds hydrostatic pressure.

3. Water Hammer Test.—Sprinklers upon original test must not burst or leak by suddenly increasing the pressure from 0 to 300 pounds, repeated 500 or more times.

4. Fusing Point.—An automatic sprinkler when intended for ordinary use must, when immersed in hot fluid, fuse at not less than 155 degrees F. nor more than 165 degrees F. Head not to be under pressure in this test. "Hard heads," in like manner must fuse at not less than 275 degrees or more than 300 degrees F. The fusing point of solder should not change with age.

5. Action in Opening.—On original test an automatic sprinkler on fusing must open without perceptible halt or hesitation at any point of the opening action. All freed parts must throw clear. This test to be made without subjecting the sprinkler to pressure, or depending upon the action of a coil spring.

6. Position.—An automatic sprinkler must be designed to open and spray satisfactorily in an upright or pendant position.

7. Distribution of Water from Sprinklers.—Sprinkler upright or pendant with deflector 4 or 6 inches below smooth ceiling and 10 feet above smooth floor:

a. Shall, under 5 pound nozzle pressure, wet ceiling over an area of not less than 3 to 4 feet in diameter.

b. Shall, when under 5 pounds nozzle pressure, throw approximately 90 per cent of water inside an area 10 feet square on floor.

c. Shall, when under 50 pounds pressure, throw not less than 75 per cent of water inside the 10 feet square area.

d. Distribution in both above tests to be approximately uniform over the 10 feet square area.

e. Water should not be cut up into fine spray.

f. Rotary deflectors are allowable, but the distribution must be satisfactory with deflector fixed.

g. The distribution in any direction shall not be obstructed by yoke, levers or other parts of sprinkler.

8. Materials.—Automatic sprinklers must contain no iron, steel or fibrous material subject to the effect of corrosion.

NOTES.—Sprinkler heads are ordinarily set to fuse at 165 degrees, 286 degrees and 360 degrees.

Corroded heads are apt to be found in chemical works, galvanizing works, sulphur bleaching looms, paper mills, sulphite and other chemical pulp mills, starch works, certain classes of dye works, and where arsenic is used for preserving skins.

"It is much more difficult to protect sprinkler heads in such factories where from the nature of the process of manufacturing the head soon becomes coated with a fine dust. This class of factories comprise flouring mills, grain elevators, saw mills, furniture factories where sand-paper drums are operated, grinding rooms in sugar refineries, candy factories, cement mills, plaster mills, drug and spice mills, etc. In all of these classes, the mere covering of the head with loose dust will only slightly retard its action; should, however, aqueous vapor be present, the fine dust soon becomes set and hardened, rendering the sprinkler head entirely inoperative. * * * This is less likely to occur in flouring mills, but is a very serious matter in cement mills, where the fine cement dust on the head, if aqueous vapors are present, will soon become as hard as stone."

"The coating of the sprinkler head with a deposit of varnish or hardened oil occurs principally in dry rooms of oilcloth factories, patent leather works, rubber works, and in fact all factories where varnish products are dried by artificial heat. The drier, in evaporating, carries with it portions of the varnish or oil, as the case may be, and this coating deposited on the cold sprinkler head, in time covers it with a coating, which, by reason of the heat of the dry room, is soon baked into a hard covering not easily removed by a fire which would ordinarily melt the fusible solder."—(Extracts from report of committee, presented by

C. A. Hexamer at the fourth annual meeting of the National Fire Protection Association.)

The approximate amount of water to fill a sprinkler system is one gallon per head for all pipe in the system, especially in systems of from 75 to 115 heads on each floor, when fed from center; if fed from one end, about 1¼ gallons; where a 6-inch riser is used with about 250 heads on a floor, about 1¼ gallons when feed is from center, and 1½ gallons when feed is from end.

The following treatment for rendering sprinkler heads not liable to corrosion is recommended by the Western Factory Insurance Association. Begin with the ordinary automatic sprinkler without any special anti-corrosion treatment. Wash the heads in lye water, rinse in clean water and let dry. Have ready a mixture of equal parts resin and paraffin. Heat the mixture to a temperature of 400 degrees, stir thoroughly, let cool to a temperature of 150 degrees by thermometer. Dip the sprinklers in this liquid, allow them to remain until the sprinkler heads are as warm as the mixture. On drawing the sprinklers out of the dip a very thin coating of the mixture will adhere. A thin coating is better than a thick coating. The coating should not be lumpy. Place the sprinklers on the pipes, being careful not to rub the mixture from off the small parts. The scraping off of the coating where the screwing-in wrench touches the shank of sprinkler, will do no harm. This treatment should last for a year or two years. After that the sprinklers and piping can be touched up with the mixture on a brush, if corrosion appears.

The following in reference to the treatment of automatic sprinkler heads to prevent corrosion is from "Hand-Book of Fire Protection for Improved Risks": Various methods have been tried for preventing or retarding corrosion, and most of these have been unqualified failures."

"Perhaps the most common coating for sprinklers found in practice is the so-called 'Nigger' head. This is a sprinkler given a thin coat of asphaltum or similar paint, and is also some times in addition to this dipped in paraffin. This method of coating a sprinkler head has not been found to be satisfactory, as it does not prevent corrosion, except, possibly, to a very slight degree, and where the corrosive influences are at all severe, the coating is entirely ineffective. It should be classed as of little value. Lead coatings have been used by various sprinkler manufacturers, but here again the protection afforded is slight, and then only under certain favorable conditions or else the sensitiveness of the head is destroyed. Paraffin coating is too soft and melts at too low a temperature for general use. Glass caps covering all but the base of sprinkler have been used in a few cases and apparently they protect the sprinkler from corrosive vapors at least temporarily" * * *

"'Corroproof' is a wax-like coating which has been used to some extent in New England, and this coating has shown up to much better advantage in practice than any of the above."

CHAPTER VIII.

STEAM FIRE PUMPS.

It is unfortunately a fact that in such an essential and important matter as the purchase and installation of a fire pump, a thing on which very often the entire protection of a plant depends, false economy is used, and an inferior and weak pump is bought and set in a poor location; it is not always the purchaser who is at fault, for some pump manufacturers, in order to secure trade by underselling competitors, place upon the market pumps of inferior construction while of apparently the same size and capacity as pumps of much higher price. It is quite an ordinary thing to find pumps in places so exposed as to be practically unreachable in case of fire; to find upon testing them that they stick, will not operate promptly, or are entirely out of order, and while the pump is known to be, as a rule, the mainstay of the fire protection, yet it usually receives less care and attention than any other piece of machinery at a plant.

UNDERWRITER STEAM FIRE PUMP.—These pumps are made under specifications as prepared by Mr. John R. Freeman, May, 1895, and are, as yet, the highest type of fire pump; the ideas in their construction is that the pump may have proper strength of parts to withstand sudden and excessive pressures, to give positive and continual maximum delivery, to withstand the action of rusting to the greatest extent, to have large steam-valve-ports, large suction-valve-areas, large water-pipe connections and in all ways to be of greater strength and better workmanship than the regular trade fire pump.

The main points of difference between the regular trade fire pump and the Underwriter Fire Pump are—brass plungers instead of cast-iron plungers, wrought-iron side levers instead of cast-iron, bronze piston-rods and valve-rods instead of iron, or steel, brass lined stuffing boxes instead of cast-iron, brass bushed rock shafts, areas of water-valves is 25 to 50 per cent greater, steam and exhaust passages 20 to 50 per cent greater, suction pipe connections two to four inches greater in diameter, cushion valves better arranged, air chamber much larger, shells and boltings are warranted especially strong.

This pump is a duplex steam pump, has size plate on inboard side of air chamber, and being brass fitted throughout and having valves and piston-rods of gun-metal composition it is rust proof. It is made strong enough to withstand 80 pounds steam pressure when all valves on water outlet pipes are closed and steam valve is wide open, and to have such arrangement of thickness of metal that it shall be safe to instantly turn a full head of steam on to a cold pump without cracking or breaking the same by unequal expansion, due to this cause. Area of steam and water valves are large. It is provided with stroke gauge, and pressure gauges for steam and water, has suitable priming pipes, a relief valve of sufficient capacity to discharge excess of water, and suction pipe has a vacuum chamber for the purpose of insuring a constant flow and regular delivery of water. Has hose connections attached to neck of air chamber.

Table of Underwriter Fire Pumps as per Specifications of J. R. Freeman, May, 1895.

Capacity at Full Speed.	Ratio of Piston Areas.	SIZE OF PUMP.
"One Stream Pump" or 250 to 320 Gallon	Four to One	12 x 6 x 12 **One Stream Pump** too small for a fire-pump, but may sometimes be all that the steam boiler of a very small factory can drive. Sometimes it is desirable at a larger factory to use this size of pump for boiler feeding, and thereby obtain one additional fire stream,— Size recommended: Diam. steam cylinder 12 ins. Diam. water plunger 6 ins. Length of stroke either 12 ins. or 10 ins.. To drive this at fire speed requires boiler of about 50 horse-power. Exact capacity Underwriter rating: For 12-inch stroke, 359 gal. per minute. For 10-inch stroke, 321 gal. per minute, For continuous use on tanks or boilers, pump should run at only about half the above speed. This size pump is adapted to feed boilers aggregating about 1200 horse-power. If a pump of smaller size must be adopted, use the 10 x 5 x 10 size. Exact capacity (Underwriter's rating) 220 gals. per minute, but for continuous service the speed should be only half this. To drive this pump at fire speed requires boiler of about 35 horse-power. This size is adapted to feed boilers aggregating about 900 horse-power.

TABLE OF UNDERWRITERS FIRE PUMPS—*Continued.*

Capacity at Full Speed.	Ratio of Piston Areas.	SIZE OF PUMP.
"Two Stream Pump" or 500 Gallon Pump	About Four to One	14 x 7 x 12. **Ordinary size for small Mills.** Exact capacity is 484 gals. per minute. This needs steam boilers of 100 horse-power capacity to drive pump at rated full speed and maintain 100 lbs. water pressure easily, but will work with 80 horse-power. A steam pressure of at least 40 lbs. at the pump needed to give this water pressure of 100 lbs. at full speed. Several manufacturers now make this 14 x 7½ x 12, which is a little better, as the exact rated capacity is 522 gals. per minute.
"Three Stream Pump" or 750 Gallon Pump	Three to One	16 x 9 x 12. **Ordinary size for general use.** Exact capacity is 807 gals. per minute. This needs steam boilers of 115 horse-power and steam pressure of at least 45 lbs. sq. in. at the pump to drive at full speed and give 100 lbs. sq. in. water pressure. For cases where boiler pressure is unusually low (less than fifty pounds), use a pump with larger (4 to 1) steam cylinder.
"Four Stream Pump" or 1,000 Gallon	Three to One	18 x 10 x 12. **Size for large Factories.** Exact capacity is 1004 gals per minute. Requires 150 horse-power boiler capacity and at least 44 lbs. sq. in. steam pressure.
"Six Stream Pump" or 1,500 Gallon	2¾ to One	**Sometimes, for very large Factories.** 20 x 12 x 16. Exact capacity is 1655 gallons per minute, and pump will readily deliver this, or seven standard streams, if set on a firm foundation and with short suction. Requires about 200 horse-power boiler and 50 lbs. steam pressure. (Two smaller pumps with same aggregate capacity are ordinarily preferred, if there is no other water supply; because when one is under repair the other will be available).

It is very rare that a smaller pump than 14 x 7 x 1 should be installed for fire service, because although present boiler may be too small to run this at full speed, a small boiler will drive a 500-gallon pump at the 300-gallon speed with very nearly as good economy as it can drive a 300 gallon pump at full speed.

TABLE OF UNDERWRITER FIRE PUMPS FROM MANUFACTURERS' CATALOGUES.

NAME.	Diameter Steam Cylinder.	Diameter Water Cylinder.	Length of Stroke.	SIZES OF PIPES.				Maker's Rated Capacity.
				Steam.	Exhaust.	Suction.	Discharge.	
BARR. Barr Pumping Engine Company, Philadelphia, Pa.	12	6	12	2½	3	6	5	300
	14	7½	12	3	4	8	6	500
	16	9	12	3½	4	10	7	750
	18	10	12	4	5	12	8	1,000
BLAKE. The George F. Blake Manufacturing Company, Boston, Mass.	12	6	12	2	3	6	5	320
	14	7¼	12	3	4	8	6	500
	16	9	12	3½	4	10	7	750
	18	10	12	4	5	12	8	1,000
	20	12	16	5	6	12	8	1,500
BUFFALO. Buffalo Steam Pump Company, North Tonawanda, N.Y.	10	5	10	2	2½	6	5	230
	12	6	12	2½	3	6	5	370
	14	7	12	3	4	8	6	504
	16	9	12	3½	4	10	7	833
	18	10	12	4	5	12	8	1,028
	20	12	16	5	6	14	10	1,904
DEANE. Deane Steam Pump Company, Holyoke, Mass.	12	6	10	2½	3	6	5	300
	14	7¼	12	3	4	8	6	500
	16	9	12	3½	4	10	7	750
	18½	10¼	12	4	5	12	8	1,000
KNOWLES. Knowles Steam Pump Works, New York, N. Y.	12	6	12	2	3	6	5	354
	14	7	12	3	4	8	6	486
	14	7¼	12	3	4	8	6	524
	16	9	12	3½	4	10	7	812
	18½	10	12	4	5	12	8	1,008
	20	11½	12	5	6	12	8	1,328
	20	12	12	5	6	12	8	1,448
	20	11½	16	5	6	12	8	1,593
	20	12	16	5	6	12	8	1,738
SMITH-VAILE. The Stilwell-Bierce & Smith-Vaile Company, Dayton, O.	12	6	12	2½	3	6	5	320
	14	7	12	3	4	8	6	500
	16	9	12	3½	4	10	7	750
	18	10	12	4	5	12	8	1,000
	20	12	16	5	6	14	10	1,500
SNOW. Snow Steam Pump Company, Buffalo, N.Y.	10	5	10	2½	3	6	5	220
	12	6	12	2½	3	6	5	360
	14	7	12	3	4	8	6	500
	16	9	12	3½	4	10	7	807
	18	10	12	4	5	12	8	1,007
	20	10	12	4	5	12	8	1,007

TABLE OF UNDERWRITER FIRE PUMPS—*Continued.*

NAME.	Diameter Steam Cylinder.	Diameter Water Cylinder.	Length of Stroke.	Sizes of Pipes. Steam.	Exhaust.	Suction.	Discharge.	Maker's Rated Capacity.
VALLEY. Valley Pump Company, Easthampton, Mass.	14	7	12					500
	16	9	12					750
	18	10	12					1,000
WORTHINGTON. H. R. Worthington, New York, N. Y.	12	7	10	2½	3	6	5	320
	14	7¼	12	3	4	8	6	500
	16	9	12	3½	4	10	7	750
	18	10	12	4	5	12	8	1,000
	20	12	15	5	6	14	10	1,250

REGULAR TRADE FIRE PUMPS.—All of the leading manufacturers of pumps make regular stock sizes of fire pumps. Since the advent of the Underwriter fire pump more attention has been given to the general construction and strength of parts in these regular trade fire pumps, and as made now, they are much in advance of the old fire pump, so-called, which usually was simply an enlarged size of a regular pattern of boiler feed pump.

TABLE OF TRADE DUPLEX AND FIRE PUMPS FROM MANUFACTURERS' CATALOGUES.

NAME.	No.	Diameter of Steam Cylinders.	Diameter of Water Cylinders.	Length of Stroke.	Size of Pipe for Short Lengths. Steam.	Exhaust.	Suction.	Discharge.	Maker's Capacity.
BARR. Barr Pumping Engine Company, Philadelphia, Pa.	B 3	9	5½	12	2	2½	5	4	268
	C 3	10	6	12	2	2½	5	5	342
	D 3	12	7	12	2½	3	6	5	480
	D 4	12	6	12	2½	3	6	5	342
	D 5	12	5½	12	2½	3	6	5	268
	E 3	14	8	12	3	4	7	6	626
	E 4	14	7	12	3	4	6	6	480
	E 5	14	6	12	3	4	6	6	342
	F 3	16	9	12	3	4	8	7	792
	F 4	16	8	12	3	4	6	6	626
	F 5	16	7	12	3	4	6	6	480
	G 3	18	10	12	3½	5	10	8	979
	G 4	18	9	12	3½	5	8	7	792
	G 5	18	8	12	3½	5	8	7	626
	H 3	20	12	12	3½	5	10	8	1,408
	H 4	20	10	12	3½	5	10	8	979
	H 5	20	9	12	3½	5	10	8	792

TABLE OF TRADE DUPLEX AND FIRE PUMPS—*Continued.*

NAME.	No.	Diameter of Steam Cylinders.	Diameter of Water Cylinders.	Length of Stroke.	SIZE OF PIPE FOR SHORT LENGTHS.				Maker's Capacity.
					Steam.	Exhaust.	Suction.	Discharge.	
BLAKE. The George F. Blake, Manufacturing Company, Boston, Mass.		10	4½	12	2	2½	5	4	240
		10	5	12	2	2½	5	5	300
		12	5	12	2	2½	5	5	300
		12	6	12	2	2½	6	5	435
		14	6	12	2½	3	6	5	435
		14	7	12	2½	3	6	6	600
		16	7½	12	2½	3	6	6	675
		16	8	12	2½	3	6	6	780
		18½	8½	12	3	3½	6	6	880
		18½	9	12	3	3½	8	7	990
		20	10	12	4	5	8	7	1,200
BUFFALO. Buffalo Steam Pump Company, North Tonawanda, N. Y.		9	4	10	2	2½	4	3	
		9	4½	10	2	2½	4	3	
		10	4½	10	2	2½	4	3	
		10	5	10	2	2½	5	4	
		12	6	12	2½	3	6	6	
		14	6	12	2½	3	6	6	
		14	7	12	2½	3	6	6	
		16	7½	12	2½	3	8	8	
		16	8	12	2½	3	8	8	
		18	8½	12	3	3½	8	8	
		18	9	12	3	3½	10	8	
		18	10	12	3	3½	10	8	
		20	10	12	4	5	10	8	
		20	10	18	4	6	10	8	
		20	12	18	4	6	12	10	
DEANE. Deane Steam Pump Company, Holyoke, Mass.		10	5	10	2	2¼	5	5	250
		12	5¼	10	2½	3	6	5	280
		12	6	10	2½	3	6	5	370
		14	6	10	2½	3	6	5	370
		14	7	10	2½	3	6	6	500
		16	7½	10	2	3	6	6	575
		16	8	10	2½	3	6	6	650
		18½	8½	10	3	4	6	6	735
		18½	9¼	10	3	4	8	7	870
		18½	9¼	18	3½	4	10	8	1,046
KNOWLES. Knowles Steam Pump Works, New York, N. Y.		10	4½	12	2	2½	4	4	240
		10	5	12	2	2½	5	5	300
		12	5	12	2	2½	5	5	300
		12	6	12	2	2½	5	5	435
		14	6	12	2½	3	5	5	435
		14	7	12	2½	3	6	6	600
		16	8	12	2½	3	6	6	780
		18½	8½	12	3	4	6	6	880
		20	10	12	4	5	8	7	1,200

TABLE OF TRADE DUPLEX AND FIRE PUMPS—*Continued.*

NAME.	No.	Diameter of Steam Cylinders.	Diameter of Water Cylinders.	Length of Stroke.	Size of Pipe for Short Lengths.				Maker's Capacity.
					Steam.	Exhaust.	Suction.	Discharge.	
SMITH-VAILE. The Stilwell-Bierce & Smith-Vaile Co., Dayton, O.		12	7	15	2½	3	6	5	308
		12	8	15	2½	3	6	5	521
		12	9	15	2½	3	7	6	660
		12	10	15	2½	3	8	7	816
		14	7	15	2½	3	6	5	398
		14	8	15	2½	3	6	5	521
		14	9	15	2½	3	7	6	660
		14	10	15	2½	3	8	7	816
		14	11	15	2½	3	10	8	987
		14	12	15	2½	3	10	8	1,174
		16	8	18	3	4	6	5	516
		16	9	18	3	4	7	6	666
		16	10	18	3	4	8	7	807
		16	11	18	3	4	10	8	976
		16	12	18	3	4	10	8	1,162
		18	9	18	3	4	7	6	666
		18	10	18	3	4	8	7	807
		18	11	18	3	4	10	8	976
		18	12	18	3	4	10	8	1,162
		18	14	18	3	4	12	10	1,582
		20	10	18	4	6	8	7	807
		20	11	18	4	6	10	8	976
		20	12	18	4	6	10	8	1,162
		20	14	18	4	6	12	10	1,582
		20	16	18	4	6	14	12	2,067
SNOW. Snow Steam Pump Co., Buffalo, N. Y.		10	6	12	2	2½	6	5	420
		12	6	12	2½	3	6	5	420
		14	6	12	2½	3	6	5	420
		14	7	12	2½	3	6	6	600
		16	7	12	3	3½	6	6	600
		16	8	12	3	3½	8	6	783
		18	8½	12	3	4	8	6	885
		18	9	12	3	4	8	7	990
		18	10	12	3	4	8	7	1,224
		20	9	12	4	5	8	7	990
		20	10	12	4	5	8	7	1,224
VALLEY. Valley Pump Co., Easthampton, Mass.		9	6	10	2	2½	6	4	300
		10	6	10	2	2½	6	4	300
		12	7	12	2½	3	6	5	500
		14	7	12	2½	3	6	5	500
		14	8½	12	2½	3	6	6	800
		16	8½	12	2½	3	6	6	800
		16	10	12	2½	3	8	6	1,000
		18½	8½	12	3	3½	6	6	800
		18½	10	12	3	3½	8	6	1,000

TABLE OF TRADE DUPLEX AND FIRE PUMPS—*Continued.*

NAME.	No.	Diameter of Steam Cylinders.	Diameter of Water Cylinders.	Length of Stroke.	SIZE OF PIPE FOR SHORT LENGTHS.				Maker's Capacity.
					Steam.	Exhaust.	Suction.	Discharge.	
WORTHINGTON. H. R. Worthington, New York, N. Y.	C	10	5	10	2	2½	5	5	250
	C C	12	5¼	10	2½	3	6	5	280
	D	12	6	10	2½	3	6	5	370
	D D	14	6	10	2½	3	6	5	370
	E	14	7	10	2½	3	6	6	500
	E E	16	7½	10	2½	3	6	6	575
	F	16	8	10	2½	3	6	6	650
	F F	18½	8½	10	3	3½	6	6	785
	G	18½	9¼	10	3	3½	8	7	850
	G G	20	9¼	10	4	5	8	7	850
	H	20	10	10	4	5	8	7	1,020
	H H	20	11	15	4	5	12	10	1,540

NOTES.—Location—Should be located in a separate fire pump house, if possible, but under all circumstances should be in a place that is readily reached and not apt to be cut off from approach in consequence of a fire in part of the plant.

Automatic Regulator.—Should be so connected in a by-pass around the throttle valve that by means of properly located cut-off valves, it can be entirely cut out from service without crippling the steam supply to the pump.

An automatic gauge should be attached to show the steam pressure at all times on all pumps used as primary supplies.

Underwriter's fire pumps should be operated at least once per week.

Regular trade fire pumps should be operated at least twice per week.

Boiler feed pumps are not made with a view to fire service, and should not be accepted as fire pumps.

Gauges should be placed on each the steam and water ends of pumps.

BOILER ROOM CONNECTIONS AND STEAM FITTINGS OF FIRE PUMPS—(An article by George Velten Steeb, published in "The Spectator," Dec. 19, 1901).—"In making the steam connections in the boiler room for a fire pump, two things must be borne in mind; first, that the throttle valve or the automatic regulator may have to be repaired at some future time, and provision must be made to allow of this without shutting down the entire plant; second, that the entire volume of steam generated by the boiler or boilers, or on the boiler or boilers at any one time, may be necessary for the proper operation of the fire pump, and that to take off any of the steam for any other purpose may seriously cripple the full efficiency of the pump; hence it is that the proper connections and valves in the boiler room should be installed at the same time that the pump is.

"The boiler room connections and valves having to do directly or indirectly with the fire pump should be as follows: i. e. (1) Every pipe from each boiler to the steam drum should be provided with a cut-off valve, so that when necessary to clean, or when fire is drawn, or in case of any accident or trouble with any one boiler, the latter can be cut out without producing the necessity of reducing the steam pressure in any other boiler; (2) every pipe taking steam from the steam drum should be provided with a cut-off valve in order that all of the steam can be shut off from everything using it in order to give the full boiler efficiency to the fire pump; (3) the steam pipe supplying the pump comes under the head of the latter, i. e. (2) for the following reason: The purpose of a cut-off valve in the steam supply pipe to the fire pump, in the boiler room, is, that in case of any repairs being needed on the steam connections or fittings of the pump, in the pump room, the steam can be shut off of the pump, in the boiler room, without affecting any other steam-using appliance about the plant, and without the necessity of reducing the boiler steam pressure.

"In repairing or replacing a leaking or broken throttle valve on a fire pump where there is no cut-off valve in the boiler room, one of three things results: the repairs must be left until the plant shuts down; or, the entire plant must be shut down until the repairs are made or the new valve placed; or, the repairs are not made on account of the necessity arising of cutting off the steam from the entire plant in order to make them, and this latter is especially the case where a plant is running day and night. Leaking throttle valves are frequently found, and in many instances are not repaired or replaced on account of the difficulty in shutting off the steam from the pump.

"In the pump room the steam supply pipe to the pump should be run down to the pump; if the pipe rises to the pump there is an increased difficulty in ridding the pipe of water from condensation; whereas, if the pipe descends to the pump the water collecting in its lowest point can be readily drawn off; therefore the supply should descend to the pump, and be carried to the steam chest of the pump by a tee to which a steam trap should be connected at its lowest end; from the horizontal opening of the tee there should be a short nipple and then the throttle valve; this valve being of the globe valve pattern. Arranged in this way, the condensation in the supply pipe will run into the tee and thus be carried off through the steam trap, and when the throttle valve is opened there will be practically no water to pass into the steam chests and cylinders with the steam.

"The throttle valve should always be placed in the horizontal pipe; if it is in the vertical pipe, the pipe above the valve is difficult to drain properly and is not apt to be thoroughly freed of its water from condensation, consequently when the throttle is opened there is a certain amount of water passing into the steam chests and cylinders with the steam.

"A globe valve should be used as a throttle valve on account of there being less of liability of leakage in this class of valve at this point than there is in a valve of the gate or cut-off pattern.

"Where two or more fire pumps are in a plant, one steam supply pipe can be taken from the steam drum in the boiler room, but each pump must have its own independent supply pipe taken off of this pipe in the boiler room, and each supply pipe must have a cut-off valve in it in the boiler room; a single pipe should not be brought into the pump room and the feed pipes for the various fire pumps be taken off of this pipe in the pump room. This is to obviate any chance of crippling all the fire pumps, in their service, by the breaking of a steam pipe, its connections, or valves in the pump room, and the consequent escapement of steam, which would probably be of such a volume as to prevent anyone remaining in the pump room to operate the other pump or pumps.

"The exhaust steam pipe should run up straight from the pump and should have no bends nor turns in it; bends and turns cause increased condensation in the pipe and are apt to retain water, which will probably drain back into the pump when the latter is at rest.

"Where two or more pumps are in the same room, each pump must have its own independent exhaust pipe, and these pipes must not, under any circumstances, be joined to one another so as to exhaust through a common pipe. If two pumps have their exhaust pipes connected, one of two things will result, i. e. (1) where there is a valve in the exhaust pipe of each pump, and when only one pump is to be run, time must be taken to close the valve, or when running one pump and desiring to change off to the other one, much time would be lost in opening one valve and closing the other, and in case of a fire the time lost might prove to be of the greatest importance; or in case of breakage of any part of the exhaust pipe or any of its connections, the exhaust from either pump would pour into the pump room and prevent the operation of either pump; or (2), if there is no valve, the pump in operation will throw a great part of the condensed steam into the other pump through its connection with the exhaust pipe, and the pump that is left at rest will, under certain conditions, operate, and under all conditions its steam cylinder will become full of water; hence, whether there are valves or whether there are no valves in the exhaust pipe, the pipe should not be connected with the exhaust pipe of any other pump under any circumstances.

"For the lubrication of the steam cylinders, the lubricant must be carried in by the steam in order to reach all parts of the cylinders. As these cylinders are usually of a good size, and a sufficient quantity of the lubricant must be supplied for adequately covering the surface needing lubrication, as well as a means of reaching this surface quickly when the pump is called upon for immediate, hard and maximum service, and as the 'sufficient quantity' at this time is certain to be a large quantity, special provision must be made in order to quickly supply a large quantity of oil to the cylinders at any time.

"A sight feed lubricator should be attached to the steam supply pipe, but not on its yoke. This class of lubricant supplier is good and adequate on nominally small cylinders in use at a practically even speed at all times, but as a fire pump is not in operation continuously, unless under the control of an automatic regulator, and then but slowly and not at the speed it would be called upon to maintain in case of a fire, a sight-feed lubricator is not an adequate lubricant supplier for a fire-pump.

"In addition to the sight-feed lubricator, a hand oil pump of nominally one pint capacity should be attached to the steam pipe yoke at the pump; then when the necessity arises of running the fire pump immediately, hard and to its maximum capacity, the oil can be thrown into the steam chests and cylinders in sufficient quantity to fully and thoroughly lubricate them at once and without delay.

"As to leaking pipes, connections and valves. The importance of preventing leaks, and, when they do occur, of repairing or replacing the leaking parts, can be readily seen. In having the connections tight and with no leaks, the assured not only keeps the condition of his fire pump and connections in the highest state of efficiency as far as the steam end of the pump is concerned, but at the same time exercises a positive economy in the operating cost of his plant.

"Take the question of fuel, which same is one of the largest items of expense in the operation of a plant; every horse power developed for its operation or protection requires a given quantity of steam, and every pound pressure of steam needs a certain amount of fuel to produce it, and every pound of coal, or every cord of wood for fuel means so much money spent, hence when a steam leak occurs and the insurance inspector asks that it be repaired or the leaking part replaced by a new and good part, the improvement requested not only tends to keep the pump and its connections in a high state of efficiency, but really shows a means for the exercise of an economy by the assured for his own benefit, for all of the steam lost through leakage is so much fuel wasted, and consequently so much money literally thrown away. Hence it redounds to the good and the profit of the assured, if only viewed from a point of a reduction in the cost of operating expenses, that a leaking throttle valve, or automatic regulator, or pipe connections should receive immediate attention and be stopped by repairs or replacing of leaking parts with good parts.

"A leaking throttle valve means not only that a 'little' steam is being lost, but that the action of the leaking steam will continue to wear away the valve, and that the loss of steam will continually become greater and greater; and the damage does not stop at the throttle valve, for the continual and continuous flow of the steam in relatively small volume and of a pressure too low to operate the pump, will in time have a bad effect on the steam valves, the cylinders and the drip cocks; it is the small amount of leaking steam that does the most damage. It follows that a leaking throttle valve should be repaired or replaced as soon as discovered, for the damage it may produce in a fire pump cannot always be estimated in advance; by wearing the drip cocks it will cause them to always leak, and the loss of pressure in the cylinders when the pump is in operation, from this cause, means a loss in the efficiency of the fire pump; the continual flow of steam through the cylinders means just so much more condensation in them; excessive water in the steam cylinder of a pump presents the liability of a cylinder head being blown off when steam is suddenly turned into the pump, and if a head is not blown off there is a resultant strain in the pump which is not good for it.

"Therefore, a leaking throttle valve means a loss of steam with the consequent cost of production, a deterioration of the steam end of the pump, and a loss of efficiency through deterioration.

"To sum up: In order to get the greatest economy and efficiency in a fire pump at its steam end (1) the connections in the boiler room must be correctly made; (2) the connections to and on the pump must also be properly made and be of the proper character; (3) all connections and fittings must be kept tight and in good order and condition."

Where pump does not take water under head, it should be primed from water tank of not less than 200 gallons capacity or its equivalent, used exclusively for that purpose; priming pipes to connect into each of the four water chambers.

Pumps must be equipped with one hose connection for each 250 gallons of rated capacity; connections to be taken directly from the pump discharge; each connection to be equipped with a gate valve.

Sufficient steam pressure and volume must be maintained at all times, when the pump is the primary or secondary supply, so that the pump can be always called on for immediate service, at full rated capacity: not less than 40 horse-power for each 250 gallons rated pump capacity, and 50 pounds pressure should be maintained as a minimum.

LOSS OF EFFICIENCY IN FIRE PUMPS, IN LIFTS, SUCTION PIPES AND SUCTION PIPE CONNECTIONS—

(An article by George Velten Steeb, published in "The Spectator," Oct. 24, 1901).—"There is more than the construction of a fire pump that is necessary to its successful operation and continued full efficiency, for the pump may be one of the very best and yet, in the setting of it, its connections, both steam and water, its method of connection for suction, its lift of suction, etc., the results given by it may be much inferior to a less well built and capable fire pump, and, therefore, the mere setting up of a good fire pump does not imply that the maximum efficiency of the pump will be realized.

"Lift.—One of the points of consideration in the best and most lasting results to be obtained of a fire pump is the lift, the suction pipe and the suction pipe connections.

"A short length and a small lift is always to be desired. A lift of more than eighteen feet at sea level is to be deprecated, for while, theoretically, a pump will lift 33.95 feet at sea level, this is figuring with a perfect vacuum and without friction; and while, practically, a pump will, with the loss of vacuum which is to be expected, and the friction in a vertical length of pipe forming a direct suction pipe for the pump, lift 25 feet at sea level, it is not well to base the lift of a fire pump on these figures, for a fire pump is expected to take water immediately (theoretically), otherwise valuable time is sure to be lost in case of a fire. A vertical lift of eighteen feet should be the maximum for short lengths of suction pipe, and it must not be understood that I advise any such lift unless the length of the suction pipe is short, the number of elbows and bends small, and that there is only one vertical and one horizontal section of suction pipe; and then, that the vertical pipe be at the pump and the horizontal pipe below the level of the water supply; there is apt to be too much to contend with in the way of leakages in joints and the reduction of a positive maximum water intake at the strainer. For long lengths of suction pipe and more than one vertical and one horizontal length of pipe the lift had better be no more than 12 feet at sea level and one foot less for each 1,500 feet above sea level. The manner of running suction pipes, in their relative order of economy of pump operation and highest degree of efficiency, is, under general conditions, as follows: (1) A vertical drop with the foot valve and strainer directly at the end of this section of vertical pipe; (2) a vertical drop with one section horizontal pipe laid below the level of the water supply; (3) a horizontal section with a vertical section at the well; (4) a vertical drop at the pump, horizontal section, a vertical section at the well.

"A vertical drop with a horizontal pipe running to a small vertical section for the foot valve connection is much preferable to a vertical drop and an inclined section running to the vertical section for the foot valve connection (2) will, of course, need a short length of vertical pipe at the well for foot valve and strainer attachment.

"Suction Pipes.—Horizontal lengths of suction pipe should be carefully laid in order to lessen the liability of air pockets in the pipe; this is, in fact, true of all pipes laid horizontally or on an incline. Air pockets in a suction pipe are detriments to the proper action of a pump, and should be obviated. An air pocket acts in different ways to retard and impede the flow of water to the water chambers; it will act by loss of air as a vacuum chamber to suck the water back, or as a cushion of compressed air to force the water back, or in the initial stages of taking suction by the pump the release of the air at the pocket will allow the air to flow into the water chambers of the pump, and thus cause a loss in the taking of the water by the pump, and any and all of these results are bad for the pump, producing hammering and a strained action.

"The fewer elbows and bends in a suction pipe the better it is for the efficiency of the pump, as friction is then reduced to a great extent and the flow is increased for the same suction force.

"Leaking suction pipes not only tend to weaken the pump but materially detract from its efficiency. If air is drawn into a suction pipe the draft of water by the action of the pump is interfered with, and not only this, but it is more difficult for the pump to hold its suction when the water is obtained, and the more difficult this becomes the greater is the strain on the pump; and the greater the strain on the pump the more is not only the efficiency lessened, but at the same time the chances of deterioration of the pump from excessive work in maintaining the suction is increased. No appliance should be depended on to do excessive work. If a manufacturer who desires to produce the best results at the least cost and expects to continue in business for a length of time, at a minimum cost of operation, finds that his engine is overloaded and has excessive strain put upon it from the overloading, he will at once take steps to remedy this fault. Then why should not the fire pump receive the same degree of attention? With the fire pump it is only a case of removing the cause, and that is done by ascertaining the location of the leak and remedying it.

"The causes of leaks in suction pipes are not many, and can be ascertained and remedied. The location of the leak will be in one of three places, i. e., at the leaded joint, at the flange joints or in the pipes, from cracks or blow holes. If in the leaded joints it is caused by poorly made joints, caused by incompetent workmen, from using too small a quantity of rope and lead (especially the latter), or from poor compacting, all of which faults can be remedied by properly calking the joints. The calking is done by thoroughly ramming tarred rope yarn and pouring upon this melted lead, which latter is prevented from spreading by a clay plaster collar on the spigot pipe at the face of the faucet (or bell) pipe; the yarn is about one to two inches in depth; the lead after pouring is compacted by a calking hammer. Untarred rope yarn is used by some pipe contractors, but tarred rope yarn does not seem to burn as much, and therefore makes a better body for the melted lead to be poured upon; also, in case of moisture, the tarred rope yarn decreases the sputtering of the melted lead. Care must be taken in all of the processes of making the joint, the rope yarn must be well rammed and a sufficient quantity of lead poured into the space between the faucet (or bell) and spigot so that, after compacting, the lead will reach to a level with the face of the faucet (or bell), but in all cases the lead must be well compacted, otherwise there will be the greatest probability of air leakage through the joint into the pipe. If in the flange joints, the remedy is to place proper packing between the flanges and then thoroughly tighten the bolts; pasteboard packing is absolutely worthless here, and a packing that will absorb and carry off water is equally poor. If in the pipes, from cracks or blow holes, the remedy is obvious—replace the leaking pipes.

"Suction Pipe Connections.—Foot-valves and strainers also need attention. The valve may have a stone or compacted earth under its seat or seats, and so allow the water in the suction pipe to run back into the well, and thus the pump is forced to lift the water from the well to the water chambers every time that it is operated, and thus extra work is put upon the pump, and extra work, when in the line of an 'effort,' should be obviated as much as possible; therefore it is necessary that the foot-valve should be occasionally examined to see that it seats properly. The strainer, in certain localities, is apt to become more or less clogged up with mud, and thus reduce the inflow of water through it; hence it should be cleaned every once in a while.

"It follows that to produce the best results and obtain the highest efficiency of a fire pump, the suction of the pump must receive decided consideration, not only in the initial stages, but ever afterward. The lift must be as small as possible, the length of suction pipe as short as possible, the manner of running the pipe and the calking of the joints must be carefully considered and carried out, and care must be given to the keeping of all the intake parts in clean and good condition."

If a pump does not take suction readily, examine the water chambers' valves; these are frequently found not seating properly and thus allowing air to suck to and fro between the chambers and so prevent proper taking hold of the suction.

CHAPTER IX.

ROTARY FIRE PUMPS.

This style of fire pump is not recommended, as it is subject to excessive rusting, being generally located in damp or wet places, and is of such construction that deterioration is practically rapid; is usually connected up with the main shaft from the water wheel and cannot be operated independent of the main shafting and counter shafting of the plant, and is more liable to breakage than a steam pump.

The pump should be located in a place easy of access and not liable to be cut off in case of a fire in any part of the plant.

Spur or cog gearing should not be used for operating the pump.

Belts should not be used for operating the pump, as the great liability of the total incapacitation of the pump through the burning of the belt is presented, and, also, the belt is apt to so deteriorate as to be of practically little service in operating the pump to its fullest capacity.

Friction gearings should be used for coupling.

A separate water wheel is advisable under all circumstances for the propulsion of the pump.

The wheel or mechanism for throwing in the gearing should be located in a protected place, easy of access, and where there is the least liability of its being cut off in case of fire.

Safety or relief valve, of the Ashton or Crosby, or some other equally good pattern, should be attached to the pump.

A pressure gauge should be attached to the pump.

Suction.—Pump to be so located in respect to its water supply that at no time shall it have a lift of over 10 feet during 60 minutes' discharge at rated capacity.—(National Fire Protection Association Standard.)

Oil.—A sufficient quantity of special quality oil should be kept at the pump for the proper lubrication of its parts.

A clutch coupling should be so located that, in case of the need of operating the fire pump, the entire shafting of the plant can be thrown out and the full capacity of the water wheel or engine be used for the operation of the pump.

In operating the pump, care must be taken that the friction clutch is thrown in tightly, so that the full power available will be realized, and also in order that the friction wheel will not heat up on account of slippage.

"The location of these pumps is usually in a wheel pit in an out-of-the-way place, subject to many variations of conditions, alternating dry and wet, hot and cold, where all parts rapidly accumulate rust. The operation involves the most dangerous conditions in mechanics. Starting a rusty device, all cast iron, perhaps in a temperature below freezing, after long disuse, putting it immediately under high velocity and excessive journal pressure invites a disaster. We rarely find them properly supplied with the right kind and quantity of lubricant, and we feel it only necessary to report that just as few of these pumps as possible should be used; that they should be located to the best advantage, as suggested by the underwriters where they have the opportunity, and that they should be provided with all the safeguards known to be needed, namely:

"First—Say a barrel of well-chosen lubricant.

"Second—A check valve to guard against the loss of water from other sources, should the pump go to pieces.

"Third—A pop or spring relief valve, to avoid dangerous pressure.

"Fourth—Securely set upon reliable foundations, to prevent vibration or strain, preferably to be driven by separate wheel.

"Fifth—If geared to the general power, all other machinery should be arranged to throw out by friction clutch at or near the pump.

"Sixth—Friction gears, or if possible to find a reliable clutch, should be the means of attaching power to the pump; both the pump and the gearing to be so securely fastened that they cannot shift when the gears or clutch are thrown in."—(From report of Committee on Rotary Pumps, as adopted by the National Fire Protection Association, at its fifth annual meeting.)

Table of Rotary Pumps from Manufacturers' Catalogues.

NAME.	Number.	Width of Bucket Faces in Inches.	Inches Between Shaft Centers.	Diameter of Suction.	Diameter of Discharge.	Gallons per Revolution.	Maker's Estimate Gallons per Minute. Moderate Speed.
Crocker Twin Rotary. E. D. Jones & Sons Company, Pittsfield, Mass.	1	5¼	5¼	3	2½	¾	250
	2	6	6	3	3	1	300
	3	7	7	5	4	1½	400
	4	8	8	5	5	2	500
	5	9	9	6	6	3	800
	6	10	9	6	6	4	1,000
	7	11	10	8	7	5	1,250
Fales & Jenks. Fales & Jenks Machine Company, Pawtucket, R. I.	4	9	9	6	5	3⅞	1,000
	5	9	8	6	5	2⅞	750
	6	8½	7	4	4	1⅔	500
	7	8	6½	4	3	1⅓	400
	7½	6½	5	3	3	⅔	200
Gould. Gould Manufacturing Seneca Falls, N. Y.	2	3⅛	4 5-16	2½	2	½	225
	3	4¾	5¼	3	2½	1	400
	4	6	6 7-16	5	4	1⅔	500
	5	5½	7 11-16	8	5	2½	750
	6	7½	9 1-5	8	6	4	1,000
Holly. Holly Manufacturing Company, Lockport, N. Y.	2	2	5	2	2	⅓	100
	3	4	5	3	3	⅔	200
	4	5	7¼	4	4	1⅓	400
	5	7	10½	5	5	2⅓	650
	6	9	10½	6	6	4½	900
	7	9	12	8 or 10	8 or 10	7	1,400
Holyoke. Holyoke Machine Company, Holyoke, Mass.	1	10	8	6	6	4	1,000
	2	9	8 4-5	6	5	3	825
	3	8½	7 1-5	5	4	2	600
Humphrey. Humphrey Machine Company, Keene, N. H.	1	6	6½	3 or 4	3	1	300
	2	6	8½	5 or 6	4	1⅓	400
	3	8	8½	6	4 or 6	1⅔	500
	4	8	10	6 or 8	6	2 2-5	600
	5	10	10	8 or 10	6 or 8	3 1-5	800
	6	12					1,000
	7	16					1,200
Hunt. Rodney Hunt Machine Company, Turners Falls, Mass.	4	9	9	6	5	3⅞	850
	5	9	8	6	5	2⅞	700
	6	8½	7 3-16	5	4	1⅔	500
	7	8	6 13-32	4	3	1⅓	400

Table of Rotary Pumps—*Continued.*

NAME.	Number.	Width of Bucket Faces in Inches.	Inches Between Shaft Centers.	Diameter of Suction.	Diameter of Discharge.	Gallons per Revolution.	Maker's Estimate Gallons per Minute, Moderate Speed.
Nonesuch. Clark Machine Company, Turners Falls, Mass.	1	4	4	3	2½	⅓	133
	2	6	5½	3½	3	¾	225
	3	8	5½	4	3½	1	300
	4	8	6½	5	4½	1½	412
	5	10	6½	5½	5	2	550
	6	12	8	6½	6	3	825
	8	12	9	8	7	5	1,250
Rodney Hunt Underwriter Rodney Hunt Machine Company, Orange, Mass.	2			10	10	6	1,500
	4			10	8	4	1,000
	5			8	8	3	750
	6			6	6	2	500
	7			6	5	1 1-5	300
Rumsey. Rumsey & Co., Seneca Falls, N. Y.	1	3⅛	4	2	2	⅓	100
	2	3½	4¾	2½	2½	6-7	250
	3	4¼	5¾	3	3	1¼	350
	4	5	7⅜	4	4	1¾	450
	5	7	8	5	5	2⅙	500
Root. P. H. and F. M. Roots Company. Connersville, Ind.	1	5	5	5	4	⅞	140
	2	6½	6½	6	5	2⅛	310
	3	8½	8½	8	6	4¼	510
	4	10	10	10	8	7	770
	5	12	12	12	10	12	1,200
Silsby Holly. Silsby Manufacturing Company, Seneca Falls, N. Y.	2	2⅞	3 13-16	2½	2½	1-5	110
	2½	3½	5	3¼	3¼	½	250
	3	4⅜	6	4	4	5-6	350
	4	6¼	6	4½	4½	1¼	450
	5	6⅛	7½	6	6	2	600
	5½	7¾	9	8	6	3⅞	1,000
	6	9	9½	8	8	5½	1,200
	7	9	10¼	9	9	7⅓	1,500
Smith. S. Morgan Smith Company, York, Pa.	3			3	2½		350 to 400
	4			5	4		500 to 580
	5			6	5		625 to 750
	6			8	6		800 to 1000

Two hundred and fifty revolutions per minute is the usual speed for fire service.

H.-P. REQUIRED FOR OPERATING ROTARY PUMPS.

250 gallon pump. 30 H.-P.	500 gallon pump. 60 H.-P.	750 gallon pump. 90 H.-P.	1,000 gallon pump. 120 H.-P.

CHAPTER X.

RESERVOIRS AND OTHER SOURCES OF WATER SUPPLY.

The supply of water for the fire pump is dependent upon the locality, the natural and artificial water courses and supplies, the "lay" of the land and the size of the supply required.

Where there is a running stream of adequate proportion and constancy the supply is easily obtained, but where the stream is not constant in its supply, or where wells have to be depended upon, the question of supply becomes more of a problem in localities especially subject to dry seasons.

Any running stream in which there is much solid matter or much matter in solution should have a settling basin or reservoir in which the solids and matters in solution can precipitate before the water is used by the pump.

Where the supply to a reservoir must be pumped from a distance to the reservoir, a double or triple plunger pump, operated by an electric motor, will be found a most excellent method, as by this system the pump can be set running from the dynamo room and does not need a man to go to it every time that it is run, hence is more certain to be in service when needed.

All water taken from ponds or running streams should be taken from cribs provided with strainers and mud-catch boxes.

During the Fall streams bring down much in the way of leaves, small sticks and other refuse, and these are liable to hold against the strainers; hence it is that the intakes should be examined periodically, especially in the Fall, so that the capacity of the intake may not be diminished.

The flow of water in head and tail races is usually swift, hence in order to get a good intake into a pump suction pipe, the foot-valve should not be too close to the surface.

RESERVOIRS.—An all-earth reservoir is not to be recommended. Defects: During the falling of rain the water will wear away the sides of the embankment and carry much mud into the bottom of the reservoir, and the bottom of the reservoir is sure to be muddy at all times, and especially so when a fire pump is running at its full capacity and taking in water rapidly, and thus producing a strong flow towards the intake, and the pump is sure to have its efficiency cut down by taking in mud.

A wooden-sided reservoir is not to be recommended on account of the rotting away of the wood, the seepage being to a considerable extent of mud, and the reduction of the pump efficiency by mud and other foreign matter being drawn in with the water.

A proper reservoir should be constructed of bricks or stone set in cement and faced with a coating of cement at least ½ inch thick in small reservoirs, and thicker in large ones. The bottom, if on a leaky soil, should be covered with at least 1½ feet of puddle for a small or medium-sized reservoir, and of greater thickness for a larger one. It is not advisable to build side walls less than 16 inches in thickness. Hard-baked brick only should be used; the cement facing will in time fall away from the soft bricks on account of the absorption of water from the earth by these bricks loosening the hold of the mortar.

Water in a reservoir should never come nearer than one foot of the top in small reservoirs, and in larger ones the distance should be greater; this is to prevent the water on a windy day from wearing away the top and edge by the waves formed by the wind.

All the ground around a reservoir should slope away from it in order to prevent surface drainage with its earthy matter from flowing into the reservoir.

Ponds.—The making of ponds by the damming up of small creeks and branches is not to be recommended in those sections of the country where the streams are subject to floods and where they run through soil that is readily soluble, as these ponds are apt to become gradually shallower and shallower until their capacity is seriously interfered with. This is especially so in a greater part of the Southern States. Where the water runs clear the year 'round a pond is to be expected to retain its capacity, but where the water is muddy the pond had better not have too much dependence placed upon its continued maximum capacity.

Where the ponds are produced by the damming up of large streams and rivers, the above results are not apt to obtain, and the supply is apt to be and remain much in excess of the amount required.

Suction Wells.—Where suction wells are used for fire pump, they should be used for this purpose alone and not have feed water or condenser pumps taking their suctions from the same well. Adequate sized pipe laid on an incline must connect the well with its source of supply, and the amount of water in the well under normal conditions should be sufficient to supply the pump at its rated capacity for at least three minutes.

CHAPTER XI.

OTHER FIRE APPLIANCES.

That efforts may be made to extinguish a fire in its incipiency, or control a fire as soon as possible before it has gained any headway, every plant should be provided with some fire-fighting appliances; those appliances which are the most easily handled and the least liable to get out of order when needed, and which require the least attention to keep them in order, are the most likely to prove of value when their services are needed. Patented devices which have not received the approval of the Underwriters should be avoided, as they are apt to prove but a waste of money in their purchase.

The quantity and character of the appliances must be governed to a great extent by the size and number of fire divisions, the character of goods or manufacturing carried on in the buildings, the exposures, and the class of help who must be depended upon to handle the appliance.

Where buildings are built of wood, or where they are built with wooden cornices, or where they have open windows not readily capable of being protected by standard fire shutters, and are directly exposed to other buildings, the danger from a fire communicating from the exposed building can be materially lessened by the use of open sprinkler heads, and these are strongly recommended under such conditions.

FIRE PAILS should be distributed in every class of risk; the most ignorant person knows what to do with a pail of water in case of a fire, and what may be expected of the water if it is thrown on the fire, hence this kind of a fire extinguishing appliance stands at the head of non-automatic appliances.

The round bottom galvanized iron pail will be found the most durable and the most lasting. Most lasting, both from the point of wear and tear, and also from the point of remaining in a plant, for it is the general habit of the help in many mills to consider fire pails as removable property.

At least twelve pails should be placed for every 5,000 feet of superficial area, but this number should be increased wherever the hazards are very great.

Pails should be properly labeled, as "Fire Pails," or "For Fire Only," and should be hung on substantial iron supports or be placed on shelves kept for this purpose only.

A specified person should be appointed to see that the pails are kept full of water and free from all foreign materials.

Pails containing chemical solutions are not recommended.

CASKS full of water should be placed in all rooms where an increased quantity of water, over that contained in the fire pails, is advisable.

BLANKETS should be provided at all points where any quantity of oil or varnish or any other material which will flow or spread, while burning, is used, as such material can be extinguished before spreading by smothering it with a blanket.

SAND in pails, or in half-barrels, or boxes, with scoops or shovels in them, should be placed at or in all oil rooms, and in all rooms where benzine, naphtha, benzole, gasolene, or any compounds containing any of the preceding liquids are used (as in boot and shoe factories, rubber works, etc.).

THERMOSTATS.—A thermostat is a device for automatically indicating a specific temperature, and giving an alarm when that temperature is reached.

Thermostats are placed on the ceiling of a room and are of a temperature operating point commensurate with the normal temperature of the room in which they are placed. The operating points for the different thermostats, i. e., high and low test thermostats, are 140, 160, 200 and 300 degrees, Fahrenheit, as per National Board of Fire Underwriters.

In localities where there is a central station the alarm is arranged to ring in the central station, and thus, even if the plant has no watchman of its own, any fire will act as its own agent in sending an alarm to a point where there is always a watchman, and thus a fire will be indicated before it has gained much headway.

In localities where there is no central station, the thermostats can be arranged to give an alarm in several different locations, as, for instance, in the office, in the superintendent's, the owner's.

the engineer's, etc., residence, and thus indicate in some specific place where some one of authority about the plant lives and where some one is reasonably sure to hear any alarm given.

DRY POWDER FIRE EXTINGUISHERS.—"So-called fire extinguishers, consisting generally of sheet metal tubes filled with mixtures of bicarbonate of soda and other materials in powdered form, are inferior for general use. Attempts to extinguish fires with them may cause delay in the use of water and other approved extinguishing agents, and therefore their introduction should not be encouraged." (Committee on Devices and Materials, National Board of Fire Underwriters, December, 1901.)

CHEMICAL EXTINGUISHERS—(National Board of Fire Underwriters)—Stationary Chemical Extinguishers.—Tank shall have a capacity of at least 250 gallons and not more than 500 gallons, and the tanks shall be at least 10 gallons, in addition to 250 gallons; for each 1,000 square feet of floor space in addition to 25,000 square feet; casements to be included in estimating floor space. Two or more tanks to be furnished where larger supplies are required.

The standpipe and connections shall be of galvanized iron pipe securely fastened in place. Galvanized iron fittings shall be used throughout and the piping coupled with threaded couplings, or right and left couplings instead of unions. Standpipe and connections must withstand a hydrostatic pressure of 300 pounds to the square inch. Standpipes connected with the tank must not be less than one-fourth inch piping, and in case of long runs or where conditions necessitate numerous changes in direction, the standpipe and connections must be of at least one and one-half inch piping. Connections shall be made with as few bends as possible and the piping so installed that it can be drained from as few points as possible, but so that the contents of all tanks can be discharged at any station where two or more tanks are installed.

A water connection at least 1½-inch with hose attached shall be installed near the tank to facilitate cleaning and refilling. Permanent fixed water connections to the apparatus are objectionable on account of the possibility of leaky valves allowing the tank and standpipe to fill.

Wire-operating cables must be of phosphor bronze. Each cable must be protected throughout its entire length by piping of not less than three-fourths inch diameter. Where more than one tank is in use each tank must be operated by independent device at each station, enclosed in one box and numbered. Operating pull or device at each station, together with the valve in connection with the hose, must be thoroughly enclosed in metal box having a glass front locked closed. Each box must contain necessary spanners and wrenches for handling hose.

Hose must be of best quality, one-inch four-ply rubber chemical hose, coupled, capable of withstanding a pressure of 500 pounds to the square inch. It must be placed at each station in baskets large enough to allow the natural coil of the hose and so that it can be pulled off in any direction. Hose reels are not recommended. Nozzles must be of brass, coated on inside with tin or lead and provided with reliable shut-off valve other than the plug-cock pattern. Discharge orifice must not be less than one-quarter inch or larger than one-half inch in diameter.

Hose stations shall be so located that hose will reach all parts of the building to be protected. Not more than 150 feet of hose, in three sections, to be placed at any one station. One hundred and fifty feet of hose to be provided only where straight runs are practicable. Additional stations with shorter hose shall be installed where stock, partitions or obstructions prevent handling long lengths. One man should be able to handle any length of hose allowable. The ½-inch nozzle should be used only where the supply tank is large and in localities such as paint factories or where more effective streams are desirable. The ¼ and ⅜ inch nozzles are usually sufficient for ordinary service.

Tank and releasing device shall be thoroughly enclosed so as to avoid tampering. Door to enclosure shall be under lock and key. Enclosures of wire work or slatted partitions are recommended so as to allow inspection.

Engine shall be so located that the temperature surrounding the same will never be less than 42 degrees Fahr.

Carbonic acid gas hand fire extinguishers must contain at least three gallons when filled to the lower edge of upper casting forming opening at the top, and at least two and a half gallons when filled to the charging line.

Must have handles firmly attached to top and bottom of the extinguisher, handle at bottom to be rigid and not hinged.

Hose must be of best quality three-ply rubber, capable of withstanding a pressure of 400 pounds to the square inch, and must be so attached to the outlet pipe that it will withstand a test pressure of at least 350 pounds to the square inch The hose must be so attached to the outlet pipe that it can be readily removed and replaced when necessary. Hose to be attached so as to hang vertically.

The hose nozzle must be of lead or other metal not subject to corrosion, have a smooth outlet not less than ⅛-inch and not more than 3-16-inch in diameter, and must be provided with a shut-off valve.

Directions for operating, for recharging, information that whenever the extinguisher is discharged it must be entirely emptied and thoroughly cleaned before refilling, and that it must be protected from frost, must be plainly and permanently marked on the shell.

The number and character of chemical extinguishers which should be placed about a plant must be left to the discretion of the inspector.

OPEN SPRINKLERS (National Board of Fire Underwriters)—To be used only on the external surface of a building.

In many cases adequate service is provided by placing only one line of sprinklers directly under a cornice. Where a small wall surface is to be protected, a good arrangement is to place one head opposite and about 6 inches below the top of every window on each floor.

Open sprinklers on the peak of a roof require a differently shaped deflector from those used at cornice, that all water may be at once deflected upon the roof, equally distributed on either side of peak.

Each open sprinkler to have an unobstructed outlet of such size and form that with five (5) pounds pressure maintained at the sprinklers it will discharge approximately 6 gallons per minute. Only approved types of open sprinklers, specially designed for the purpose, to be used. Opened automatic sprinklers are not acceptable.

It is to be remembered that in a system of open sprinklers all are operated at one time, and with a system of any size there is a considerable quantity of water discharged per minute. For that reason outlet of each open sprinkler is made smaller than that of an automatic sprinkler. A three-eighth-inch plate or ring orifice will give the discharge desired.

Not over 12 open sprinklers to be installed at one side of feed-point on one line of pipe, and these not to be located over 8 feet apart "on the line." Open sprinklers are to be arranged on piping not smaller than that used for automatic sprinklers.

The schedule of pipe sizes for "branch lines" does not apply to open sprinklers having ⅜-inch thin plate orifice or its equivalent.

Supply to open sprinklers to be town water works, standpipe, pump or steamer connection, but never pressure or gravity tank used to supply automatic sprinklers. Riser for open sprinklers to feed into the line at centre and not to be supplied from any point which would actuate a properly located alarm valve of the automatic sprinkler system, whether or not such an alarm valve is provided. Valve controlling the supply to be located at a safe distance from the exposure and readily accessible. All pipes and fittings in such a system to be carefully arranged so that water can be entirely drawn from same.

Perforated Pipes can be installed under the same provisions as to valves supplies as open sprinklers, but they are not recommended as being of the same possible value as the open sprinklers. The holes in the pipes being small, are liable to be plugged up by dust, etc., and the pipes may be rendered totally valueless from such a cause.

STEAM JETS can be used to great advantage in enclosed spaces; the space, however, should not be subject to draft, for the steam in passing through would be apt to suck the fire with it and spread it, instead of extinguishing it. A pipe of adequate size, with a gate valve located in it at a point readily reached and accessible at all times, should be connected so that the full boiler pressure and volume will be available.

LADDERS should be kept at all isolated plants, and at all plants with buildings over two stories in height and which have a private fire brigade.

PIPES.—Only standard cast iron tar-coated water pipe, as per Rules and Requirements of the National Board of Fire Underwriters, should be used for the underground piping for hydrants and sprinkler system supply, excepting for the pipe between an air valve and the sprinkler system supplied from the valve; this pipe should be wrought iron.

UNDERGROUND PIPES AND FITTINGS (National Board of Fire Underwriters)—Hydrant mains must not have any 4-inch pipe.

For pipes extending to a dead end, allow 200 feet of 6-inch pipe with one 3-way hydrant, 500 feet 6-inch with one 2-way hydrant (this might be extended in special cases), 1,000 feet 8-inch with one 3-way hydrant, 500 feet 8-inch with one 4-way hydrant or its equivalent in hose streams, and 300 feet 8-inch to first hydrant where there is a hydrant equivalent of 6 streams. Whereas, the above limitations for 8-inch pipe are low, it is deemed undesirable to have over 4 streams on a dead end, and the loop system would ordinarily be employed where it is intended to concentrate over 4 streams at one point. Never allow more than three (3) streams on 6-inch branch pipe.

For loop systems with two 3-way hydrants, say 250 feet apart, allow 250 feet 6-inch pipe from each hydrant toward source (preferably use 8-inch pipe with 3-way hydrant systems). With two 2-way hydrants, say 250 feet apart, allow 500 feet 6-inch pipe from each hydrant toward source. With three 2-way hydrants 250 feet apart allow 250 feet 6-inch pipe from end hydrants toward source. To feed four 2-way hydrants or their equivalent, use 8-inch main feed pipes and allow 500 feet of 8-inch pipe each way from end hydrant to water supply, rest of pipe 6-inch, if desired. To feed five 2-way hydrants or their equivalent use 8-inch main feed and allow 250 feet from end hydrants to water supply.

HYDRANTS.—The general design, quality of material, size and all other points involved in the construction and character of a hydrant for private fire systems have been adopted by the National Board of Fire Underwriters, and thus a standard has been formulated.

Each hose outlet of a hydrant should be equipped with a gate valve.

The number of and size of hydrants must be dependent upon the size of the plant to be protected by them.

Standpipes.—Outside standpipes at fire escapes, or permanent ladders with hose connections at each floor, may prove of great service. Should be 3 inches in diameter, with hose connections same size as on hydrants.

Inside standpipes are frequently made use of, and, if kept in good order and in readily reached localities, can be made of great value in extinguishing small fires. Should be at least 2 inches in diameter.

Fire pumps of plant can be used as a supply, and where there is a reservoir of large capacity and with sufficient pressure it may be used alone or in conjunction with the fire pumps, but the supply must be of such a character and so arranged as not to interfere with the supply of water for automatic sprinkler system.

If the public water supply is connected, in addition, to the fire pump or reservoir there should be a check valve in the connecting pipe near the public water main.

Gate valve and drain pipe should be in each outside standpipe at base, and, in locations where there is a public fire department, a check valve and connection for fire engine hose should be at the ground, the check valve being below the hose connection; these will permit the drawing off of all water from the pipe, and thus prevent water freezing in the pipe, and will allow a fire engine to give its full pressure on the pipe.

HOSE, whether cotton rubber lined or linen, must be "National Standard" hose.

For mill yard use only cotton fabric rubber lined is acceptable. This hose must be made in accordance with the Rules and Requirements of the National Board of Fire Underwriters. Must be 2⅝-inch in internal diameter, have U. S. gun metal couplings, with the name of the manufacturer stamped on them in letters ¼-inch high; be marked with a special color line woven into the fabric, and branded with a special name to indicate that it is "National Standard" hose, and such color line or brand must be used only for hose conforming to these requirements; be marked with the maker's name and with the year and month of manufacture, stenciled in two places, with indelible ink, the marks being five (5) feet from the couplings; be marked with the words "National Standard." All the markings, except color line, must be black and white letters 1 inch high.

Manufacturers will not be required to guarantee hose against effects of wear and tear of use, injury from fire, acids, or any cause not due to defects of manufacture, but if at any time during a period of two (2) years from the date of delivery of a lot of hose a section or sections of it burst when subjected to a pressure of less than 150 pounds, or show signs of weakness which is evidently due to defects of manufacture, and not at all incident to the customary wear and tear of use, such quantity of defective hose should be replaced by new hose without further cost to the consumer.

Each outside hose house should contain 150 feet or 200 feet of hose, according to the height of the building to be protected and the distance apart of the hydrants.

The amount of hose to be placed for service at outside and inside standpipes must depend upon the area supposed to be covered from the hose connection; ¾ to 1¼-inch hose.

Hose after use should always be drained of the water remaining in it.

Fire hose should only be used for the purpose of fire or tests by inspectors.

Three-quarter-inch to 1¼-inch hose, with ⅜-inch to ½-inch nozzles, will prove to be the most serviceable for inside standpipes; long lengths should not be used. Hose should be carefully coiled or folded on racks used for that purpose only, and should only be in readily accessible places.

Outside standpipes should be provided with single lengths of cotton rubber-lined hose.

Hose Houses.—A frame house of ample size, weather proof sides and roof and well ventilated, should be placed over each hydrant and over the hose connections from the fire pump when they project through the walls of the pump house. The doors should be so placed that when they are open the hose attached to the hydrant can be used without causing a sharp bend in it at the house. The five-sided hose house as designed by the Factory Insurance Association is of the very best type, and should be built wherever possible.

Besides the hose, each house should be equipped with 2 Underwriters' play pipes (1⅛-inch smooth nozzles, swivel handles, 30-inch long tapering tube, wound and painted), 1 to 2 axes, 1 to 2 crowbars, 4 to 6 taber spanners, 1 lantern, 2 hydrant wrenches, a liberal supply of rubber hose washers, and ladder straps and coils of rope.

Hose to be properly folded on shelves, two lengths coupled together and attached to hydrant and with play pipe attached at other end. Other equipment to be properly hung up on hangers.

PRIVATE FIRE BRIGADE.—All plants having fire pump, hose or other fire appliances should organize and maintain a private fire brigade thoroughly instructed in the use and handling of the fire appliances. Regular drills in propitious weather should be held. The Chief should be a man of experience and authority.

CHAPTER XII.

OILS, VARNISHES, BENZINE, ETC.

The care and handling of oils, benzine and other explosive, volatile and highly inflammable liquids are points for careful oversight, as but a small and apparently safe cause very often is sufficient to produce a disastrous result. Benzine, camphene, benzol, naphtha and gasolene are all highly inflammable volatile liquids, hence their use in closed rooms or near any lights or fires is very dangerous. Cleanliness, care in handling and safe storage locations are very essential to safety.

Illuminating and lubricating oils kept in rooms of the plant should not be in quantities of more than one barrel of a kind, and should be kept in metal or metal-lined wooden cabinets.

At ordinary temperature gasolene continually gives off inflammable vapor, and a light some distance from the material will ignite it through the medium of this vapor. The vapor from one pint of gasolene will make 200 cubic feet of air explosive. It depends upon the proportion of air and vapor whether it becomes a burning gas or destructive explosive. Beware of any leaks in cans, and never forget how dangerous a material you are handling.

Where there is no fireproof oil, etc., house, benzine, benzol, naphtha, gasolene and cements and compounds containing these liquids should only be kept in very small quantities, in metal cans and outside of the building (on window sills, fire escapes or any other convenient place).

Supply of benzine, benzol, naphtha and gasolene and compounds containing any of the above should be kept in and "drawn off" in fire-proof houses or rooms, or in a building at least 100 feet from any other building of the plant.

Heating, mixing or thinning of any cement or compound containing benzine, naphtha or gasolene should not be allowed in any building other than building separate from all other insured buildings by at least 100 feet, and used especially for that purpose.

In varnish and paint factories, etc., supply of oils and turpentine should be kept in oil houses or in outside iron tanks. In supplying oil, etc., to any fire-heated mixing kettles, it should be carried by hand, pumped or forced by air pressure, but never flowed by gravity. Small supply tanks inside of paint factories should be of iron, raised at least 12 inches above the floors, and should be filled by pumps or by air pressure; filling these tanks direct from the barrel by gravity is not a good practice. It is much safer to feed oil, etc., to paint mills, etc., by pumps or air pressure than by hand or gravity.

Gutta-percha cement, sole-laying cement, oil-proof or any cement or compound containing benzine or naphtha which requires heating before use, is absolutely forbidden.

Rubber cement, sole-laying cement, oil-proof or any cement or compound containing benzine or naphtha which is used cold (for use in boot and shoe factories, rubber factories, glazed and patent leather factories, etc.) must not be inside of buildings other than oil or cement houses in any quantity greater than one day's supply, and should be used from approved safety cans wherever possible.

Benzine, naphtha, gasolene, benzol and any cements, cleaning fluids and compounds containing any of the above liquids must not be used near any artificial lights.

Cleaning fluids of benzine, naphtha, gasolene or compound containing any of the above should be used from approved safety can only (printing houses, tailor shops, cloak and clothing factories, jewelry factories, etc.).

Oils, varnishes, benzine, naphtha, gasolene, turpentine, alcohol, etc., must never be kept in glass receptacles.

Oil used for fuel for boilers, singeing machines, heaters, etc., should be fed to the burners by pumps or air pressure. Where a gravity feed is used, the main supply tank should discharge into as small a secondary tank as possible, and the burners be fed from the latter; when the secondary supply tank is full a gate valve in supply pipe from main tank to secondary tank should be closed, and should only be open while secondary tank is being filled, and this should be as seldom as possible. Main tank should be at least 150 feet from buildings where a gravity feed is in use.

Oils for lubricating should be carefully selected, as poor oils produce friction of bearings through overheating and gumming. These oils should not flash under 300 degs. where used on heavy or fast running machinery.

All lamps, lanterns, etc., should be filled in daylight, over a metal pan.

All varnishes, oils, etc., should be kept as much as possible in metal receptacles, but where they are drawn through spigots from the barrels there must be a metal drip pan under each spigot.

Oil should not be dipped out from any barrel.

Oil cabinets should preferably be raised a few inches from the floors, and the floors under them be covered with sand.

Oils for stock (hemp, jute, wool, etc.) should be handled in as small quantites as possible.

Illuminating oils should not flash under 110 degs. Illuminating oils, see Notes, Chapter V.

Lubricating oils should not flash under 300 degs., and where fast-running or heavy machinery is used the flashing point for the oil or grease should not be under 500 degrees.

To remove oil from wood, thoroughly wash the oil-soaked wood with a strong solution of caustic soda, lye or potash.

A volatile liquid is one that will evaporate rapidly and spontaneously, such as benzine, gasolene, ether, etc.

Oils, varnishes, etc., spread rapidly on water as well as on other substances, and will float and burn on water, therefore an oil house should never be set over any stream that flows toward any buildings, and should not be placed on an elevation sloping toward any building.

For oil room construction, see Chapter II.

Lamp rooms should, as far as possible, be of the same construction as oil rooms, but where lamps are kept in an open main room they should always be stood in stamped metal pans, and never be on wood, for no matter how carefully a lamp is filled there is sure to be some oil on the outside of it, and this oil will be absorbed by any wood that the lamp may be placed upon, and all oils render wood more combustible than the wood is without the oil.

CHAPTER XIII.

OILY WASTE AND OTHER SPONTANEOUSLY COMBUSTIBLE MATERIAL.

There are many unknown combinations of materials, as well as known combinations, which produce spontaneous combustion, and as with the known combinations the actual conditions necessary to produce the combustion cannot be absolutely stated and always overcome, hence it is that where even the remotest suspicion of spontaneously combustible or of excessive and dangerously overheating combinations are thought to exist, special care should be taken to avert any possible danger. Oily cotton waste, when not absolutely saturated with oil, is subject to spontaneous combustion by the action of the capillary attraction of the threads for the oil, pulling the oil along a thread until resistance is met with at a knot or tangle and here producing heat of a sufficiently high temperature to ignite the small quantity of oil passing and thus fire all the waste, or waste with a small quantity of oil on it may be so exposed to the rays of the sun or other heat rays as to produce combustion; when cotton waste is thoroughly saturated with oil the danger is practically reduced to a minimum. The rapid absorption of oxygen by vegetable and animal oils, especially when in small quantities, as is the rule with cotton wiping waste and cloths when carelessly left around, produces sufficient heat to cause spontaneous combustion in the oily waste. Spontaneous combustion is also produced in the following, viz.: Cotton, woolen articles, hemp, jute, tow, flax and rags when impregnated with oil and left in accumulated piles; oily metal filings and cuttings, especially when a very small quantity of water is added; strong nitric or sulphuric acid on wool or straw, accumulations of board scrapings in currying shops, fleshings in tanneries, empty nitrate of soda bags, press cloths in soap, rendering, oil, butterine, etc., factories, oiled silk, oily leather scraps, oily waterproof clothing and oily overalls and clothing, as in quantities these generate sufficient heat in themselves to produce combustion; piles of fish scrap, green bone, unslaked lime whether in piles or barrels, lamp black in packages or any other form, hay, cotton, woody fibre, tow, flax, hemp, jute, rags, leaves, spent tan, cocoanut fibre, straw in manure heaps, tow lying upon a barrel of rosin, some kinds of coal (bituminous) when sufficiently moistened with water; all of these materials under certain conditions generate heat sufficient to fire spontaneously.

Oily metal cuttings and filings should be removed from buildings daily and kept at least 20 feet from any buildings.

Board scrapings in currying shops, etc., should not be kept inside of buildings, except when in metal cans raised 2 inches above the floors.

Fleshings in tanneries should be removed daily and never piled against the sides of any buildings, except a building specially built for them and at least 30 feet from the insured buildings.

Nitrate of soda bags when emptied should be immediately removed to vacant ground over 25 feet from the buildings, or put in a fireproof building or a building constituting no hazard to other buildings of the plant, or be put in water; no bags should be stored in main building until they are thoroughly washed and dried.

Water on sodium will cause combustion by oxidization, hence it is that it must be kept dry. The same is true of potassium.

Bisulphide of carbon is a volatile liquid with a low ignition point, about 300 degs. F.

On account of rapid oxidization chlorate of soda when mixed with organic substances and acids will cause combustion, hence it needs close attention. It is used extensively in dye works.

Nitric acid in contact with hay will cause the hay to ignite.

Fish scrap and green bones in fertilizer factories should be kept in a well-roofed and sided building, so as to be protected from rain and other forms of moisture.

Unslaked lime should be kept in a well-roofed and sided building, so as to be protected from rain and other forms of moisture.

Press cloths in soap, rendering, oil, sterine, etc., works, packing-houses, etc., should be thoroughly washed and dried before being piled together.

Scraps of oil silk, oily leather, oiled waterproof clothing, celluloid, etc., should never be allowed to lay about in piles, but should be gathered up and removed daily.

Oily overalls, jumpers and other clothing should be hung against brick walls or placed in fireproof closets.

Lampblack should be kept in a perfectly dry place, preferably in a covered metal can.

Excelsior used for rubbing and finishing in paint shops, furniture factories and other risks where painting and varnishing are done should be kept in self-closing early waste cans when not in use, and remove and burn at least once daily. Keep all early waste in self-closing metal waste cans when not in actual use, and empty these cans daily.

Always have plenty of ventilation where any material subject to, or in which there is the least suspicion of a liability to, spontaneous combustion, is kept.

A majority of the spontaneously combustible materials need a small quantity of water to cause them to become overheated, and thus become a fire; hence all materials subject to or in which there is the least suspicion of a liability to spontaneous combustion should be kept in water and weatherproof buildings.

CHAPTER XIV.

WASTE AND RUBBISH.

More carelessness is exhibited in the disposal of rubbish and waste than with any other thing inherent to a risk; whether the carelessness is in consequence of neglect, a lack of efficient supervision or from a "don't-care" disposition one cannot always judge, but it is a very common thing to see the middle of a floor, the passageways and stairs thoroughly swept and clean, while accumulated waste and rubbish is found in corners, under benches, counters, machinery, in closets, etc., and when such a condition of affairs is pointed out to a proprietor or superintendent it is always received with a look of astonishment and either an assurance that it will not occur again or an explanation that "to-morrow" or "Saturday" is cleaning day and everything will be removed then, or that there is "no danger of that getting afire, as there is nothing in it to set it on fire." It is much more important to have closets, corners, spaces under counters, benches and machinery clean than to have the "always seen" places clean, for there is more liability to fire in practically concealed spaces than in open spaces, and a fire starting in a concealed space is more apt to be serious than one starting in an open space. The care of the accumulated waste and rubbish is also an important matter, for no one can be certain just what may be mixed in with it, and spontaneously combustible materials, unknown to the sweeper and others, may be part of it. All vaults, bins, conveyors, etc., should be carefully and properly built and located. No hot materials, such as ashes, should be put in wooden receptacles, and systematic and careful sweeping, cleaning and removal of all rubbish and waste should prevail.

Ashes.—Here lies one of the most constant and most universal hazards, for it is inherent in all classes of risks—manufacturing, business and dwelling. There is always a possibility of ashes being put into their receptacle while still hot, or being put into some corner where some rubbish or other inflammable material has been thrown, or of being thrown against a wooden partition, post, side of a building, etc.; hence it is that care should be given to the elimination of this hazard wherever possible. Only riveted metal ash cans should be used; wooden barrels and boxes should be discarded. If ashes are thrown into a pile it must be seen that the location of this pile is such that it is away from all inflammable materials, and that no rubbish, papers, sweepings, etc., are thrown on the same pile.

Clean waste paper can be bagged and stored in some place not exposed to any lights or heating appliances which might be liable to set them on fire through contact; they should never be left loose in any quantities.

Cobwebs should always be removed, as they tend to collect dust and so are rendered inflammable and made rapid carriers of fire.

Conveyors carrying dust, lint, etc., from machines (textile mills, flour mills, polishing and buffing machines, woodworking plants, etc.), should be of galvanized iron riveted, securely supported or hung, be provided with sufficiently large fans to carry off all of the dust, etc., made by the machines connected with them, and be provided with automatic cutoffs, in order that no fire can travel back through them. They should not run over the tops of boilers or any other heat-generating appliances, excepting in boiler rooms in sawmills, where the boiler fires are fed through feed holes opening on the tops of the brickwork of the boiler.

All dust in bark mills, flour mills, grain elevators, grist mills, rag mill rooms in paper mills, leach houses, and all lint in textile mills should be regularly and systematically removed daily, if possible, but weekly certainly.

Dust from buffing and polishing machines can be carried into water tanks, if this is preferred.

Dust rooms should be well ventilated. The system of cyclone dust separators is advised wherever applicable.

Lint should be removed from gins, linters, cards and all other textile machines, practically continually.

All mill waste of textile mills should be removed to a detached building daily.

Rubbish and Sweepings.—All buildings should be swept out daily. In mercantile buildings where there is any great quantity they should be kept in a vault under the sidewalk or in a properly constructed fireproof room until they are removed from the building. Only riveted metal cans, the bottoms of which are raised at least 3 inches from the floors, should be used as waste cans. In manufacturing plants the rubbish and sweepings should be removed from the buildings daily. In sweeping care must be taken that all corners, under and behind all benches, under and behind all steam and other pipes, closets, bottoms of elevator shafts and all dark and generally unnoticed places receive as thorough a cleaning as the middle of the floors.

Vaults.—Doors between vaults and firerooms must be kept closed, except while material is being removed from the vault, and no material must be carried directly from the vault to the fires while the door is open. Doors on vaults should, if possible, be at least 10 feet from the fire openings and not directly in front of the fires, but if directly in front, should be at least 20 feet distant. Care must be taken not to leave a trail of sawdust, etc., between the doors and the feed pile in the boiler room.

All rubbish, etc., should be removed from under street gratings, for it is here exposed to ignition by a person passing on the street dropping a lighted match, cigar or cigarette down upon it.

CHAPTER XV.

SPECIAL INFORMATION.

MACHINERY.—Notwithstanding the special care generally given to all power appliances by the employment of engineers to keep watch over all such apparatus, it is not exceptional to find shafting out of "line" and so running in the bearings as to produce overheating, or to see pulleys and belting in contact with wood, and causing by their movements undue heating, or to find unused loose pulleys wobbling on shafting and presenting the liability of the production of a spark at any time.

Bearings are usually found well oiled, but covers for the oil or grease cups are often missing where absolutely necessary on account of dust mixing in with the exposed oil or grease.

All heavy machinery (such as large engines, gang saws, band saws in sawmills, rollers in rubber, plaster, etc., works, heavy stamping machines, rollers in rolling mills, etc.) should have heavy foundations independent of the building structure.

Shafting must be regularly looked after to see that it is in "line" and running cool.

All journals and bearings should be in full sight, accessible and kept well oiled and clean.

Approved self oilers should be used wherever possible.

All oil cups, especially in places exposed to dust (such as flour mills, grain elevators, plaster mills, etc.), must be covered by good, tight-fitting metal covers.

Metal drip pans should be under all bearings, and journals which drip oil or grease, and under all machines using oil on their work (such as nut, bolt and screw machines, some lathes, etc.).

Where there is a continual liability to overheating (as at crank shaft of gang saws in sawmills), a stream of water should constantly be flowed over such place while it is in motion.

All loose pulleys no longer in use must be removed.

Hangings for shafting must be securely and rigidly fastened to their supports.

Each head in a grain elevator must be so arranged as to be "thrown out" of connection with operating machinery, independently of any other head, while the machinery is running at full speed. Friction gearing for operating heads from main shaft should preferably be used.

GASOLENE ENGINES (National Board of Fire Underwriters)—Should be located on the ground floor wherever possible, and where in rooms where dust and inflammable flyings prevail they must be enclosed in a properly constructed fireproof compartment well ventilated to the outer air at both the floor and the ceiling; if set on a wooden floor the engine must be on a metal plate turned up at the edges. The supply tank shall be located outside of the buildings, underground, where possible, at least 30 feet from the buildings and below the level of the lowest pipe in the building used in connection with the system. Where it is impracticable to bury the tank it may be installed in a noncombustible building or vault properly ventilated, preferably from the bottom. The use of auxiliary inside tanks is not advised, as extra piping and fittings are required, and an additional receptacle containing gasolene is introduced within the building, but if such a tank is used it shall not exceed one quart in capacity and shall not be placed on, in or under the engine, and shall be so arranged that when the supply valve is closed a drain valve into the return pipe will be automatically opened. The piping from the outside tank shall run in as direct a line as possible, not in the same trench with the other pipe nor near any other pipe, and the openings in the walls of the building where the pipes enter shall be securely cemented and made water and oil tight. The piping for the feed and the overflow auxiliary inside tank and feed cup shall be installed with a good pitch, so that the gasolene will drain back to the supply tank. The fill and vent pipes leading to the surface of the ground shall be boxed or jacketed to prevent freezing of earth about them and loosening or breaking of connections. The muffler or exhaust pot shall be placed on a firm foundation, and be at least one foot from woodwork or combustible materials, and the exhaust pipe, whether direct from engine or from muffler, shall extend to the outside of the building, and be kept at least 6 inches from any woodwork or combustible material, and if run through floors or partitions shall be provided with ventilated thimbles, and shall in no case discharge into chimneys. Due consideration shall be given the cleaning of the cylinder, valves and exhaust pipe as often as the quality of the fuel necessitates.

Engine room floors should preferably be of cement or asphalt, but if of wood a covering of metal should be placed over it at all points where oil is apt to be thrown.

Partitions of wood against which oil is apt to be thrown should be protected by the placing of a metal shield in such a location as to intercept the thrown oil, or if this is not possible the partition should be covered with sheet metal closely following all angles and lines. This metal covering should be put on with lock joints and soldered.

Printing and lithographic presses and all machines using oil on work done on them (screw, bolt, nut, etc., machines) should preferably be set on cement, concrete or asphalt floors, but where set on wood the wood should be covered with metal wherever there is any possibility of oil being dropped or thrown.

When repairs are to be made at night, or are to be made in some dark place by artificial light other than electric light, no less than two men together should attend to the work.

Belt holes should be as small as possible, while yet giving sufficient room for play of belt. They should all be provided with metal or wood curbing, i. e., raised castings or strips of wood at their upper edges, in order to prevent floor sweepings, rubbish, water, etc., from falling through them.

MISCELLANEOUS ITEMS.—Empty boxes, boards, etc. should always be piled in an orderly manner, away from all liability of contact with any lights, in a readily accessible location, and the floor about these piles should be kept free and clean.

Closets, in sprinkled risks, should, unless provided with sprinkler heads within them, have no wooden or metal tops to them. Where used for hanging workmen's clothes in, for keeping tools, as supply closets or where any machinery, parts of machines, oils or any materials of an oily or spontaneously combustible nature are kept, they should have the doors made of wire netting, so that the whole interior of the closet is always in full view.

GUNPOWDER.—Under no circumstances must it be handled near any artificial lights or fire-heating appliances. The quantity that can be kept in or near a building is regulated in localities by local laws and regulations.

Where matches are kept in large quantities (as in retail and wholesale grocery risks), they should be piled on the floor in piles of more than three cases high; in piles up to three cases they can be piled on low counters or shelving not over 4 feet high. This is to prevent the liability of the boxes from falling any distance, and thus firing the matches.

Where straw, hay, excelsior or loose paper is used for a packing material, it should be kept in standard tin-lined bins or boxes, with standard tin-clad doors or covers on them. Only one bale of straw, hay or excelsior should be opened at one time. All loose when packing is finished should be put back into its receptacle.

Sawdust should not be used to absorb oil drip unless the sawdust is in an open metal pan, and is taken out daily.

Smoking should be prohibited in and about all manufacturing plants, and should be restricted in all business buildings.

All sooty deposits should be removed, and all places liable to such deposits should be protected by metal pans with the edges turned at right angles toward the point from which the deposit emanates.

Stacks of wood-burning fires from which sparks fly (as at sawmills, etc.) should be provided with spark arresters.

Stairways and passageways should always be kept free of any obstructions.

Ground bark from tannery bark mills should be conveyed to the leach tanks in a moistened condition, so that there will be a minimum of flying dust; steam jets at the discharge of each bark mill are advised for this purpose.

Timbers, rafters and all woodwork in any location subject to deposits of dust or any inflammable or combustible materials should be thoroughly whitewashed with a solution of lime, salt and alum, or be painted with some fireproof paint.

Unused machinery should always be cleaned of oil and any oily materials which may be on it.

Window glass has been known to so concentrate the rays of the sun as to set fire to light inflammable materials. Where there is any liability of any such thing the plain glass should be replaced with ribbed glass, glazed glass or the glass should be painted.

Sawdust should not be used in spittoons; substitute sand.

All fire appliances should be regularly examined by some specified person in order to insure a reasonable certainty of their being in perfect order for immediate service at all times.

Use sand, not sawdust, for the absorption of oil on floors at machines, where lamps are filled, and at all places where oil is liable to be absorbed by wood.

CHAPTER XVI.

WATCHMAN AND WATCHMAN'S TIME RECORDING APPARATUS.

It is recommended that a steady, sober, middle-aged man be employed as watchman (for nights, Sundays, holidays and all times when a risk is not open or running), in all risks, but more especially is this urged in manufacturing plants, isolated buildings, and in localities where there are no public fire or police departments.

Clock.—The Rules and Requirements of the National Board of Fire Underwriters for the installation and use of watchmen's time-recording apparatus call for a clock that will run eight days, that dials cannot be seen without opening its door, that the opening or closing of the door will make a distinctive record on the dial, that the records be made by perforating a paper. The stations to be located as required. If magnetos are used they must be enclosed in dust-proof cases, and where in damp places or where subject to corrosive influences, to be in moisture-proof case, and if a battery system is used, connections operating clocks to be made by use of a special key box, and not by press buttons. In wiring preference to be given to a system so arranged that it is difficult to "beat" by short circuiting or connecting to wires at a point other than the station or clock.

Stations should be so located that in order to make a complete circuit of them it will be necessary to pass in view every part of the entire plant.

Rounds should be made at least once every hour.

CHAPTER XVII.

MISCELLANEOUS INFORMATION AND TABLES.

Exposures, whether direct or indirect, can only, in all cases, be determined by existing conditions, such as the character of the exposure as to construction, as to contents, as to intervening air spaces and ventilations as to distances, as to relative heights, etc., and can be best provided against only by careful examination as to conditions and circumstances. It is not only that one building exposes another, but also that a light or heating appliance exposes some inflammable material, and whether it is one kind or another kind of an exposure, it should be provided for by parapet walls, fire doors and shutters, bricking up openings, removing exposed woodwork or covering it with lock-jointed tin or asbestos, or by providing ventilation or by proper fire appliance equipment.

Fire Appearances.

	Fahr. Deg.
Red, just visible	977
Red, dull	1,290
Red, cherry, dull	1,470
Red, cherry, full	1,650
Red, cherry, clear	1,830
Orange deep	2,010
Orange, clear	2,190
White heat	2,370
White bright	2,550
White dazzling	2,730

Areas of circles are to each other, theoretically, as the squares of their diameters, hence doubling the diameter of a pipe practically increases its capacity four times. The discharges from pipes under the same head of water are to each other as the square root of their fifth power.

To find the area of a circle, multiply the square of the diameter by .7854, or multiply half the diameter by half the circumference.

The diameter of a circle is equal to the circumference divided by 3.1416, and, inversely, the circumference is equal to the diameter multiplied by 3.1416.

All machines producing dust in their operations should be provided with dust conveyors for carrying the dust outside of the building proper into dust rooms. Wherever possible cyclone dust arresters should be used.

TABLE OF ELECTRIC HORSE POWER.

Formula: E. M. F. (in volts) × C. (in amperes) + 746 = H. P.

Current in Amperes.	E. M. F. in Volts.														
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
	Electric Horse Power.														
5	0.06	0.13	0.20	0.28	0.33	0.40	0.47	0.53	0.60	0.67	0.73	0.80	0.87	0.93	1.
10	0.13	0.28	0.40	0.53	0.67	0.80	0.93	1.07	1.20	1.30	1.40	1.60	1.74	1.90	2.
20	0.28	0 53	0·80	1.07	1.30	1.60	1.90	2.10	2.40	2.70	2.90	3.20	3.50	3.70	4.
30	0.40	0.80	1.20	1.60	2.20	2.40	2.80	3.20	3.60	4.00	4 40	4.80	5.20	5.60	6.
40	0.52	1.07	1.60	2.10	2.60	3.20	3.70	4.20	4.80	5.30	5.90	6.40	6.90	7.50	8.
50	0.67	1.30	2.00	2.60	3.30	4.00	4.60	5.40	6.00	6.70	7.40	8.00	8.70	9.40	10.
60	0.80	1.60	2.40	3.20	4.00	4.80	5.60	6.40	7.20	8.00	8.80	9.60	10.40	11.20	12.
70	0.93	1.90	2.80	3.70	4.60	5.60	6.50	7.50	8.40	9.40	10.30	11.20	12 30	13.10	14.
80	1.02	2.10	3.20	4.20	5.40	6.40	7.50	8.50	9.60	10.70	11.80	12.80	13.90	15.00	16.
90	1.20	2,40	3.60	4.80	6.00	7.20	8.40	9.60	10.80	12.00	13.20	14.40	15.60	16.90	18.
100	1.30	2.70	4.00	5.30	6.70	8.00	9.40	10.70	12.00	13.40	14.70	16.00	17.40	18.70	20.
110	1.40	2.90	4.40	5.90	7.40	8.80	10.30	11.80	13.20	14.70	16.20	17.60	19.10	20.60	22.
120	1.50	3.20	4.80	6.40	8.00	9.60	11.20	12.80	14.40	16.00	17.60	19.20	20.90	22.50	24.
130	1.60	3.50	5.20	6.90	7.70	10.40	12.30	13.90	15.60	17.40	19.10	20.90	22.60	24.40	26.
140	1.90	3.70	5.60	7.50	9.40	11.20	13.10	15.00	16.90	18.70	20.60	22.50	24.40	26.20	28.
150	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.

For type cleaning lye should be used in place of benzine, etc., wherever possible.

Marking Ink.—A good ink is made of one pound extract of logwood, one ounce bichromate of potash and one gallon of hot water.

Non-Freezing Mixture for Fire Casks and Pails.—A strong, saturated solution of salt and bicarbonate of soda (common washing soda), with one pound of ammonia added to each five pounds.

Whitewash.—A good, lasting and partly fireproof whitewash is made of slaked lime in a brine in which as much salt and alum have been dissolved as the water will take up.

Basements.—In manufacturing plants a basement 3 feet above ground level is counted a story.

In counting the number of floors in a building from the outside, begin with the top floor and count down, as there is less liability to mistake in counting down than in counting up.

Each nominal horse power of boilers requires 7½ gallons, or 1 cubic foot of water per hour.

UNITED STATES STANDARD GALLON OF WATER.

Cubic Inches in Gallon.	Weight of a Gallon in Pounds.	Gallons in a Cubic Foot.	Weight of a Cubic Foot of Water in Pounds.
231	8.33111	7.480519	62½

240.07 gallons weigh one ton of 2000 pounds; 1000 gallons weigh about four and one-sixth tons.

Water expands in freezing about 1-12 of its bulk, in the ratio of from 1,000 to 1,086, or 8.55 per cent., and when rigidly confined it is estimated that the expansive force approximates 30,000 pounds per square inch. If the ice in forming is not free to expand longitudinally with the pipe, the resultant pressure would approximate 10,000 pounds per square inch.

Multiplying the height of a column of water by .434 will give the pressure in pounds per square inch. Approximately, every foot of elevation is equal to ½-pound pressure; this allows for ordinary friction. An elevation of 2.31 feet gives a pressure of 1 pound per square inch.

TABLE SHOWING THE PRESSURE OF WATER AT DIFFERENT ELEVATONS.

Feet Head.	Equals Pressure per Square Inch.	Feet Head.	Equals Pressure per Square Inch.	Feet Head.	Equals Pressure per Square Inch.	Feet Head.	Equals Pressure per Square Inch.	Feet Head.	Equals Pressure per Square Inch.
1	.43	20	8.66	75	32.48	130	56.31	185	80.14
2	.87	25	10.82	80	34.65	135	58.48	190	82.30
3	1.30	30	12.99	85	36.82	140	60.64	195	84.47
4	1.73	35	15.16	90	38.98	145	62.81	200	86.63
5	2.16	40	17.32	95	41.15	150	64.97	205	88.80
6	2.60	45	19.49	100	43 31	155	67.14	210	90.96
7	3.03	50	21.65	105	45.48	160	69.31	215	93.14
8	3.40	55	23.82	110	47.64	165	71.47	220	95.30
9	3.90	60	25.99	115	49.81	170	73.64	225	97.49
10	4.33	65	28.15	120	51.98	175	75.80	230	99.63
15	6.49	70	30.32	125	54.15	180	77.97		

THEORETICAL DISCHARGE OF CIRCULAR ORIFICES. DIAMETERS IN INCHES.

Tapering Smooth Nozzles will give about 82 per cent of this discharge. Ring Nozzles will give about 64 per cent of this discharge.

HEAD.		NUMBER OF UNITED STATES GALLONS DISCHARGED PER MINUTE.						
Pounds.	Feet.	⅝	¾	⅞	1	1⅛	2	2½
10	23.1	23.6	53.2	72.2	94.4	119	378	590
15	34.7	28.7	65.1	88.4	116	146	463	723
20	46.2	33.4	75.3	102	134	169	534	835
25	57.8	37.2	84.1	114	149	189	597	933
30	69.3	40.9	92.2	125	164	207	654	1,022
35	80.9	44.2	99.6	135	177	223	707	1,104
40	92.4	47.2	106	142	189	239	755	1,180
45	104 0	50.2	113	153	200	253	801	1,252
50	115.5	52 8	119	161	211	267	845	1,320
55	127.1	55.4	125	169	221	280	886	1,385
60	138.6	57.8	130	177	231	293	925	1,446
65	150.2	60.2	136	184	241	305	964	1,506
70	161.7	62.5	141	191	250	316	999	1,561
75	173.3	64.6	146	198	359	327	1,034	1,616
80	184.8	66.6	150	204	267	338	1,068	1,669
85	196.4	68.8	155	210	275	348	1,101	1,720
90	207.0	70.8	160	217	283	358	1,133	1,770
95	219 5	72.8	164	223	291	368	1,164	1,820
100	231.1	74.6	168	228	299	378	1,194	1,866
105	242.6	76.5	172	234	306	387	1,224	1,912
110	254.2	78.3	177	239	313	396	1,253	1,957
115	265.7	80.1	181	245	320	405	1,281	2,002
120	277.3	81.8	184	250	327	414	1,308	2,044
125	288.8	83.5	188	255	334	422	1,335	2,086

TABLE OF PRESSURE OF WATER PER SQUARE INCH CONVERTED INTO FEET HEAD OF WATER.

Pounds per Square Inch.	Feet Head.	Pounds per Square Inch.	Feet Head.	Pounds per Square Inch.	Feet Head.
1	2.31	8	18.47	40	92.36
2	4.62	9	20.78	50	115.45
3	6.93	10	23.09	60	138.54
4	9.24	15	34.63	70	161.63
5	11.54	20	46.18	80	184.72
6	13.85	25	57.72	90	207.81
7	16.16	30	69.27	100	230.90

TABLE OF RELATIVE DISCHARGING CAPACITIES OF FULL SMOOTH PIPES.

This table takes into consideration the impeding of the flow of water by imperfections in the interior surface of the pipes due to corrosive and incrusting action of the water or other causes. (From R. D. Wood & Co.'s catalogue)

DIAMETER IN INCHES.												Diameter in Inches.
3	4	6	8	10	12	14	16	18	20	22	24	
....	....	32.00	15.59	8.92	5.66	3.85	2.76	2.05	1.58	1.24	1.	24
....	71.00	25.74	12.54	7.18	4.55	3.10	2.22	1.65	1.27	1.	....	22
....	55.94	20.28	9.88	5.66	3.59	2.44	1.75	1.30	1.	....	....	20
....	43.00	15.59	7.59	4.35	2.76	1.87	1.34	1.	....	....	....	18
65.80	32.03	11.61	5.66	3.24	2.05	1.40	1.	....	....	....	....	16
47.12	22.93	8.31	4.05	2.32	1.47	1.	....	....	....	....	....	14
32.05	15.60	5.66	2.76	1.58	1.	....	....	....	....	....	....	12
20.32	9.89	3.59	1.75	1.	....	....	....	....	....	....	....	10
11.63	5.66	2.05	1.	....	....	....	....	....	....	....	....	8
5.66	2.76	1.	....	....	....	....	....	....	....	....	....	6
2.05	1.	....	....	....	....	....	....	....	....	....	....	4
1.	....	....	....	....	....	....	....	....	....	....	....	3

The last vertical column gives the diameters in inches, as does also the horizontal column at the head of the table.

The numbers at the intersections of the diameters in inches of the horizontal and vertical columns give the approximate relative discharging capacities. For instance, if it is desired to know how many smaller pipes a 12-inch pipe is equal to in discharging capacity, trace along the horizontal line from the 12-inch diameter in the vertical column, and it will be found that it is equal to 15.60 4-inch pipes, or 2.76 8-inch pipes, etc.

WROUGHT IRON WELDED PIPE.

INSIDE DIAMETER.	OUTSIDE DIAMETER.	EXTERNAL CIRCUMFERENCE.
Inches.	Inches.	Inches.
⅛	.40	1.272
¼	.54	1.696
⅜	.67	2.121
½	.85.84	2.652
¾	1.05	3.299
1	1.31	4.134
1¼	1.66	5.215
1½	1.9	5.969
2	2.37	7.461
2½	2.87	9.032
3	3.5	10.996
3½	4.	12.566
4	4.5	14.137
4½	5.	15.708
5	5.56	17.475
6	6.62	20.813
7	7.62	23.954
8	8.62	27.096
9	9.68	30.433
10	10.75	33.772

Pipes.—Wrought iron, for pipes, has the great advantage over cast iron of lightness, toughness and pliability, although it corrodes much more rapidly.

On account of irregularity in sizes of pipes, pipes not being laid straight, quality of water, etc., in long lengths of pipe it is expedient to make the diameter, even for temporary purposes, sufficiently large to discharge at least 20 per cent more than quantity desired.

In sprinkler equipments cast iron pipes are used in all places excepting between an air valve and the system it feeds.

CAST IRON PIPE SIZES, IN INCHES.

Diameter.	Circumference.	Diameter.	Circumference.	Diameter.	Circumference.
½	1.57	1¾	5.50	6	18.85
¾	2.36	2	6.28	8	25.13
1	3.14	3	9.43	10	31.42
1½	4.71	4	12.57	12	37.70

Cast iron tar-coated water pipe for mill yard use, by the Rules and Requirements of the National Board of Fire Underwriters, must be coated, after the pipe is cleaned without the use of acids or other liquids, by immersing it, when at a temperature of 300 degs. F., in a bath of coal-pitch varnish of an equal temperature. The hydrostatic and hammer test for this pipe is as follows: When coated the pipe must be subjected to a test by hydrostatic pressure of not less than three hundred (300) pounds per square inch for all pipe 12 inches in diameter or under, and two hundred and fifty (250) pounds per square inch for all sizes above 12 inch; and while under such pressure the pipe must be subjected to an additional test by a series of blows at various points throughout its entire length with a three (3) pound hammer attached to a handle sixteen (16) inches long. If any failure is shown in the pipe during this test it shall be rejected.

CARRYING CAPACITY OF SEWER PIPE, GALLONS PER MINUTE.

SIZE OF PIPE.	1-Inch Fall per 100 Feet.	2-Inch Fall per 100 Feet.	3-Inch Fall per 100 Feet.	6-Inch Fall per 100 Feet.	9-Inch Fall per 100 Feet.	1-Foot Fall per 100 Feet.	2-Foot Fall per 100 Feet.	3-Foot Fall per 100 Feet.
3-inch	13	19	23	32	40	46	64	79
4-inch	27	38	47	66	81	93	131	163
6-inch	75	105	129	183	224	258	364	450
8-inch	153	216	265	375	460	527	750	923
9-inch	205	290	355	503	617	712	1,006	1,240
10-inch	267	378	463	755	808	926	1,310	1,613
12-inch	422	596	730	1,033	1,278	1,468	2,076	2,554
15-inch	740	1,021	1,282	1,818	2,224	2,464	3,617	4,467
18-inch	1,168	1,651	2,022	2,860	3,508	4,045	5,704	7,047
24-inch	2,396	3,387	4,155	5,874	7,202	8,303	11,744	14,466

Closing of Valves.—Valves in pipes containing running water under pressure should be closed slowly, in order to overcome the sudden, hence excess, pressure consequent upon the quick closing of the valves, as the sudden arresting of the momentum of the flowing water will create a greater pressure in the pipes and present a liability of causing them to burst.

Sylvester's Process for Repelling Moisture from External Walls.—The process consists in using two washes or solutions

Friction of Water in Pipes.

Friction-loss in pounds pressure per square inch for each 100 feet of length in different size clean iron pipe discharging given quantities of water per minute. G. A Ellis, C E.

Gallons per Minute.	Sizes of Pipes—Inside Diameter.														
	¾ In.	1 In.	1¼ In.	1½ In.	2 In.	2½ In.	3 In.	4 In.	6 In.	8 In.	10 In.	12 In.	14 In.	16 In,	18 In.
5	3.3	0.84	0.31	0.12	----	----	----	----	----	----	----	----	----	----	----
10	13.0	3.16	1.05	0.47	0.12	----	----	----	----	----	----	----	----	----	----
15	28.7	6.98	2.38	0.97	----	----	----	----	----	----	----	----	----	----	----
20	50.4	12.3	4.07	1.66	0.42	----	----	----	----	----	----	----	----	----	----
25	78.0	19.0	6.40	2.62	----	0.21	0.10	0.027	----	----	----	----	----	----	----
30	---	27.5	9.15	3.75	0.91	----	----	----	----	----	----	----	----	----	----
35	----	37.0	12.4	5.05	----	----	----	----	----	----	----	----	----	----	----
40	----	48.0	16.1	6.52	1.60	----	0.20	----	----	----	----	----	----	----	----
45	----	----	20.2	8.15	----	----	----	----	----	----	----	----	----	----	----
50	----	----	24.9	10.0	2.44	0 81	0.35	0.09	----	----	----	----	----	----	----
75	----	----	56.1	22.4	5.32	1.80	0.74	0.23	----	----	----	----	----	----	----
100	----	----	----	39.0	9.46	3.20	1.31	0.33	0.05	----	----	----	----	----	----
125	----	----	----	----	14.9	4.89	1.99	----	----	----	----	----	----	----	----
150	----	----	----	----	21.2	7.0	2.85	0.69	0.10	----	----	----	----	----	----
175	----	----	----	----	28.1	9.46	3.85	----	----	----	----	----	----	----	----
200	----	----	----	----	37.5	12.47	5.02	1 22	0.17	----	----	----	----	----	----
250	----	----	----	----	----	19.66	7.76	1.89	0.26	0.07	0.03	0.01	----	----	----
300	----	----	----	----	----	28.06	11.2	2.66	0.37	0.09	0.04	----	----	----	----
350	----	----	----	----	----	----	15.2	3.65	0.50	0.12	0.05	0.02	----	----	----
400	----	----	----	----	----	----	19.5	4.73	0.65	0.16	0.06	----	----	----	----
450	----	----	----	----	----	----	25.0	6.01	0.81	0.20	0.07	0.03	----	----	----
500	----	----	----	----	----	----	30.8	7.43	0.96	0.25	0.09	0.04	0.017	0.009	0.005
750	----	----	----	----	----	----	----	----	2.21	0.58	0.18	0 08	----	----	----
1,000	----	----	----	----	----	----	----	----	3.88	0.94	0.32	0.13	0.062	0.036	0.020
1,250	----	----	----	----	----	----	----	----	----	1.46	0.49	0.20	----	----	----
1,500	----	----	----	----	----	----	----	----	----	2.09	0.70	0.29	0.135	0.071	0.040
1,750	----	----	----	----	----	----	----	----	----	----	0.95	0.38	----	----	----
2,000	----	----	----	----	----	---	----	----	----	----	1.23	0.49	0.234	0.123	0.071
2,250	----	----	----	----	----	----	----	----	----	----	----	0.63	----	----	----
2,500	----	----	----	----	----	----	----	----	----	----	----	0.77	0.362	0.188	0.107
3,000	----	----	----	----	----	----	----	----	----	----	----	1.11	0.515	0.267	0.150
3,500	----	----	----	----	----	----	----	----	----	----	----	----	0.697	0.365	0.204
4,000	----	----	----	----	----	----	----	----	----	----	----	----	0.910	0.472	0.263
4,500	----	----	----	----	----	----	----	----	----	----	----	----	----	0.593	0.333
5,000	----	----	----	----	----	----	----	----	----	----	----	----	----	0.730	0.408

for covering the surface of the brick walls through which water seeps. One solution is composed of castile soap and water in the proportion of three-quarter pound of soap to one gallon of water, and the other solution is composed of alum and water in the proportion of half-pound of alum to 4 gallons of water. Both the soap and the alum must be thoroughly dissolved in the water before being used.

The wall should be perfectly clean and dry, and the coating should only be done when the temperature of the air is above 50 degrees F.

The first, or wash soap, should be laid on when at boiling heat with a flat brush, taking care not to form a froth on the brick-work; this should remain for 24 hours, so as to become dry and hard before the second, or alum wash, is applied. The alum wash should be applied in the same manner as the soap wash, the temperature of the alum wash when applied may be 60 or 70 degrees F., and it also should remain 24 hours before applying a second coat of soap wash. These coatings are to be repeated alternately until the walls are made impervious to water.

The alum and the soap thus combined form an insoluble compound, filling the pores of the masonry and entirely preventing the water from penetrating the walls.

TABLE SHOWING DIMENSIONS AND CAPACITY OF STANDARD WATER TANKS.

Diameter.		Height.		Capacity.
6 Feet.	0 Inches.	5 Feet.	11 Inches.	1,000 Gallons.
8 "	6 "	5 "	11 "	2,000 "
10 "	8 "	5 "	11 "	3,000 "
11 "	9 "	5 "	11 "	4,000 "
13 "	3 "	5 "	11 "	5,000 "
8 "	3 "	7 "	11 "	2,500 "
10 "	8 "	7 "	11 "	4,000 "
12 "	5 "	7 "	11 "	6,000 "
10 "	4 "	9 "	11 "	5,000 "
12 "	5 "	9 "	11 "	7,500 "
11 "	10 "	11 "	10 "	8,000 "
13 "	8 "	11 "	10 "	10,000 "
16 "	0 "	11 "	10 "	15,000 "
18 "	8 "	11 "	10 "	20,000 "
20 "	2 "	11 "	10 "	25,000 "
28 "	6 "	11 "	10 "	50,000 "

In applying this method the author of this book found that one pound of soap would cover approximately 130 square feet, and one pound of alum would cover approximately 800 square feet.

The capacity of a rectangular tank in gallons is found by multiplying its inside length, breadth and height together (to find its cubic contents), and dividing this result, if in inches, by 231, or multiplying it, if in feet, by 7.4805.

CAPACITY OF "ROUND" TANKS IN GALLONS FOR EACH FOOT IN DEPTH FROM 4 FEET TO 16 FEET IN DIAMETER, ADVANCING BY ¼ FEET.

Diameter		Gals.	Diameter.		Gals.	Diameter.		Gals.	Diameter.		Gallons.	Diameter.	Gallons.
Ft.	In.		Ft.	In.		Ft.	In.		Ft.	In.		Ft.	
4	0	93.94	7	3	308.77	10	6	647.69	13	9	1,110.63	20	2,350.
4	3	106.06	7	6	330.39	10	9	678.88	14	0	1,151.39	22	2,844.
4	6	118.93	7	9	352.63	11	0	710.82	14	3	1,192.91	24	3,384.
4	9	132.54	8	0	375.94	11	3	743.51	14	6	1,235.17	26	3,971.
5	0	146.83	8	3	399.80	11	6	776.87	14	9	1,278.10	28	4,606.
5	3	161.86	8	6	424.41	11	9	811 05	15	0	1,321.79	30	5,288.
5	6	177.65	8	9	449.77	12	0	846.03	15	3	1,366.22	32	6,016.
5	9	194.18	9	0	475.80	12	3	881.51	15	6	1,411.40	36	7,617.
6	0	211.45	9	3	502.65	12	6	917.87	15	9	1,457.25	40	9,400.
6	3	229.41	9	6	530.18	12	9	954.97	16	0	1,503.92	45	11,897.
6	6	248.18	9	9	558.45	13	0	992.82	17	0	1,698.	56	14,688.
6	9	267.63	10	0	587.47	13	3	1.031.84	18	0	1,903.	60	21,151.
7	0	287.83	10	3	617.17	13	6	1,070.61	19	0	2,121.		

The capacity of a "round" or cylindrical tank in gallons is found by multiplying the area of the average circle between its top and bottom by its height and dividing this result, if in inches, by 231, or multiplying it, if in feet, by 7.4805, or by multiplying the square of its average diameter by 5.87.

The capacity of an elliptical tank in gallons is found by multiplying the product of the diameters by .7854, and this by the height, and dividing their result, if in inches, by 231, or multiplying it, if in feet, by 7.4805.

Cypress lumber is the best wood for tanks, as it is more durable than pine or cedar and does not shrink or swell as much as other tank woods.

Wooden tanks are best for locations where the tank is outside and continuously exposed to the weather. Iron and steel tanks properly kept painted are as lasting as wooden tanks, but in the average plant no care whatever is given to such a matter as the painting of the tank, and unless the metal tank is cared for, it will deteriorate more quickly than the wooden tank.

NOTE.—The figures (page 182) for ring nozzle discharges will apply to any ordinary form of ring accurately enough for practical purposes, but apply especially to ordinary form of ring nozzle with square shoulder, 1-16 or ⅛-inch deep.

Ring nozzles with "under-cut" or "knife-edge" shoulder discharge as ordinarily constructed about 3 per cent less than quantity given in Table B, No. 1, page 182.

The degree of accuracy attained in estimating discharge through "Open Butts" is not nearly so great as may be attained by the methods of the two preceding tables—B. No. 1 and B. No. 2—by reason of greater influence of form of hydrant and differences in hose.

Pressure gauge should be attached to hydrant; if not, proper allowance must be made for loss of pressure between gauge and hydrant.

NOTE.—Slight peculiarities of construction in different makes of hydrants so affect discharge from open butts of hydrants without hose that these figures apply only approximately to discharge of hydrants in general.

By using good judgment in applying corrections, as per notes page 185, results accurate to within 10 per cent may generally be obtained.

(Style A).—Ordinary Matthews (R. D. Wood & Co.'s) hydrant without independent gates, inside corner being rounded off, will probably discharge about 20 per cent. more.

(Style B).—Ordinary Chapman hydrants without independent gates have square inside corners, will probably discharge about 10 per cent more.

For the ordinary Ludlow & Lowry independent gate hydrants or chucks, figures in tables are probably nearly correct.

PUMP INSPECTION TABLES.

Table B, No. 1. (From experiments of J. R. Freeman, 1888.)

Discharge of Nozzles attached to 50 feet of 2½ inch Hose. Quantities are stated in U. S. gallons of 231 cubic inches.

A—Unlined Linen Hose. B—Inferior Rubber-lined Cotton "Mill Hose," Inside Rough. C—Ordinary best quality Rubber-lined Hose, Inside Smooth.

Hydrant Press. Indicated While Stream is Flowing by Gauge Attached to Hyd'nt.	Smooth Nozzle (Gallons Per Minute).																		Ring Nozzle (Gallons per Minute).									Hydrant Pressure.
	1⅜-Inch.			1¼-Inch.			1⅛-Inch.			1-Inch.			⅞-Inch.			¾-Inch.			1⅜-Inch.			1¼-Inch.			1⅛-Inch.			
Lbs. per Sq. In.	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	Lbs. per S. I.
5	90	92	103	80	82	90	70	71	75	59	59	62	47	47	48	36	36	37	75	76	84	66	67	70	56	56	59	5
10	127	131	146	114	116	127	99	101	107	83	84	87	66	67	68	50	50	51	108	110	118	94	96	101	80	81	84	10
15	155	160	179	140	143	154	121	123	131	101	102	106	81	81	84	61	61	62	132	135	144	115	117	124	98	99	103	15
20	180	185	206	161	164	179	140	142	151	117	118	123	93	94	96	71	71	72	152	155	167	133	135	143	113	114	119	20
25	201	207	230	180	184	200	156	158	169	131	132	137	104	105	107	79	80	81	170	174	187	149	151	159	126	128	133	25
30	220	226	251	197	202	219	171	173	184	143	144	150	114	115	118	86	87	88	187	191	205	163	165	175	138	140	145	30
35	238	245	272	213	218	236	184	188	199	154	156	162	123	124	127	93	93	95	201	206	221	176	179	189	149	151	157	35
40	255	262	291	227	233	253	197	201	213	165	167	173	132	133	136	100	100	101	215	219	237	188	191	202	159	162	168	40
45	270	278	309	241	247	269	209	213	226	175	177	184	140	141	144	106	106	108	229	233	251	200	203	214	169	172	178	45
50	284	293	325	255	260	283	221	224	238	184	186	194	147	148	152	112	112	113	241	245	264	211	214	226	179	181	186	50
55	298	307	341	267	273	296	232	235	250	193	195	204	154	155	159	117	117	119	253	257	277	221	224	237	187	189	197	55
60	311	320	357	279	285	309	242	245	261	202	204	213	161	162	167	122	122	124	264	269	289	231	234	247	196	198	205	60
65	324	333	371	290	296	322	252	255	272	210	213	221	168	169	173	127	127	129	275	280	301	240	244	257	205	206	214	65
70	336	346	385	301	307	334	261	265	281	218	221	230	174	176	180	132	132	134	285	291	313	249	253	267	212	213	222	70
75	348	358	399	311	318	344	270	275	291	226	228	238	181	182	186	137	137	139	295	301	324	258	262	276	219	221	230	75
80	359	370	412	322	329	357	279	284	301	233	236	246	186	188	192	141	142	144	305	311	334	266	270	285	226	228	237	80
85	371	382	425	332	339	369	288	293	310	240	243	253	192	193	198	145	146	148	314	320	345	274	279	294	233	235	244	85
90	381	393	437	341	349	379	296	301	319	247	250	261	197	199	204	149	150	152	323	329	355	282	287	303	239	242	252	90
95	392	403	449	350	358	390	304	309	328	253	257	268	203	204	209	153	154	156	332	338	364	290	295	311	246	249	259	95
100	402	414	461	359	368	400	312	317	337	260	264	275	208	210	215	158	159	161	340	347	374	298	303	319	253	255	266	100

PUMP INSPECTION TABLES.

Table B, No. 2. (From experiments of J. R. Freeman, 1888.)

Discharge of Nozzles attached to 100 feet of 2½-inch Hose. Quantities are stated in U. S. gallons of 231 cubic inches.

A—Unlined Linen Hose. B—Inferior Rubber-lined Cotton "Mill Hose," Inside Rough. C—Ordinary best quality Rubber-lined Hose, Inside Smooth.

Hydrant Press. Indicated While Stream is Flowing by Gauge Attached to Hyd'nt.	Smooth Nozzle (Gallons Per Minute).																		Ring Nozzle (Gallons Per Minute).									Hydrant Pressure.
	1⅜-Inch.			1¼-Inch.			1⅛-Inch.			1-Inch.			⅞-Inch.			¾-Inch.			1⅜-Inch.			1¼-Inch.			1⅛-Inch.			
Lbs. per Sq. In.	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	Lbs. per S. I.
5	75	79	93	70	72	82	62	64	71	54	55	59	44	45	47	34	34	35	67	69	76	60	62	68	52	53	57	5
10	107	111	131	98	102	116	88	91	100	76	78	83	63	63	66	48	49	50	94	97	110	85	87	96	74	75	81	10
15	131	136	160	121	125	143	108	111	123	93	95	102	76	77	81	59	60	61	115	120	135	104	107	117	90	92	99	15
20	151	157	185	139	144	164	125	128	142	107	110	118	88	89	94	68	69	71	133	138	155	120	123	135	105	107	114	20
25	169	176	207	155	161	184	139	143	158	120	122	132	99	100	105	76	77	79	149	154	174	134	138	151	117	119	128	25
30	185	192	226	170	176	202	152	156	173	132	134	144	108	110	115	84	84	87	163	169	191	147	151	165	128	130	140	30
35	200	208	245	184	190	218	165	169	188	142	145	156	117	119	124	90	91	93	176	182	206	159	163	179	139	141	151	35
40	214	222	262	197	204	233	176	181	201	152	155	167	125	127	133	97	97	100	188	195	219	169	174	191	148	151	162	40
45	225	236	278	209	216	247	187	192	213	161	165	177	132	134	141	103	103	106	200	207	233	180	185	203	157	160	172	45
50	239	249	293	220	228	260	197	202	224	170	174	186	139	142	148	108	109	112	211	218	245	190	195	214	165	169	181	50
55	251	261	307	231	239	273	207	212	235	178	182	195	146	148	155	113	114	117	221	229	257	199	204	224	173	177	189	55
60	261	273	320	241	250	285	216	222	245	186	190	204	153	155	162	118	119	122	231	239	269	208	213	234	181	185	198	60
65	272	284	333	251	260	296	225	231	255	194	198	213	159	161	169	123	124	127	241	248	280	217	222	244	189	192	206	65
70	282	294	346	261	270	307	233	240	265	201	205	221	165	167	176	128	129	132	250	258	291	225	230	253	195	199	213	70
75	292	304	358	270	279	319	241	248	275	208	212	228	171	173	182	132	133	137	259	267	301	233	239	262	203	206	221	75
80	301	314	370	278	288	329	249	256	284	215	219	236	177	179	188	137	138	142	267	275	311	240	246	270	209	213	228	80
85	311	324	382	287	297	339	257	264	293	222	226	243	182	185	193	141	142	146	275	284	320	247	254	279	215	219	235	85
90	320	333	393	295	306	349	264	272	301	228	233	250	188	190	199	145	146	150	283	292	329	255	261	287	222	226	242	90
95	329	342	403	303	314	358	272	279	309	234	239	257	192	195	204	149	150	154	291	300	338	262	269	296	228	232	249	95
100	337	351	414	311	322	368	279	287	317	240	245	264	197	200	210	153	154	158	299	308	347	269	275	302	234	238	255	100

PUMP INSPECTION TABLE.—"OPEN BUTTS."

Table B.—No. 3. (From experiments of J. R. Freeman, 1888).

HYD. PRESS.	QUANTITY OF WATER DISCHARGED PER MINUTE THROUGH ORDINARY 2½-INCH FIRE HOSE, WITH COUPLINGS OF 2½-INCH BORE. (U. S. GALLON OF 231 CUBIC INCHES.) OPEN HOSE BUTTS. NO PLAY PIPE OR NOZZLE ATTACHED.													DIS. THROUGH OPEN BUTT OF HYD. WITHOUT HOSE ATTACH'D	
Indicated while stream is Flowing by Gauge Attached to Hydrant.	Length 25 Feet.			Length 50 Feet.			Length 100 Feet.			L'gth 200 Ft.		L'gth 300 Ft.		Hyd. Press. Ind. while Stream is Flow. by Gauge Attached to Hyd.	Diam. of Outlet Exactly 2½ In. Disch. of one Nipple of Chapman 4-way Ind. Gate Hyd.
	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill" Hose. Inside Rough.	Ordinary Best Quality Rubber-lined Hose. Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill" Hose. Inside Rough.	Ordinary Best Quality Rubber-lined Hose. Inside Smooth.	Unlined Linen Hose.	Inferior Rubber-lined Cotton "Mill" Hose. Inside Rough.	Ordinary Best Quality Rubber-lined Hose. Inside Smooth.	Inferior Rubber-lined Cotton "Mill" Hose. Inside Rough.	Ordinary Best Quality Rubber-lined Hose. Inside Smooth.	Inferior Rubber-lined Cotton "Mill" Hose. Inside Rough.	Ordinary Best Quality Rubber-lined Hose. Inside Smooth.		
Lbs. pr. Sq. In.	If hydrants were of style A, discharge would be 5 per cent greater.	If hydrants were of style A, discharge would be 5 per cent greater.	If hydrants were of style A, discharge would be 9 per cent greater.	If hydrants were of style A, discharge would be 8 per cent greater.	If hydrants were of style A, discharge would be 8 per cent greater,	If hydrants were of style A, discharge would be 6 per cent greater.	If hydrants were of style A, discharge would be 1½ per cent greater.							Lbs. per Sq. In	Gals. per Min.
10	231	242	297	176	188	242	132	140	188	102	140	74	102	10	419
15	283	297	363	217	230	297	161	171	230	125	171	90	125	15	518
20	326	343	419	251	266	343	168	199	266	144	199	104	144	20	592
25	365	383	468	281	297	383	208	222	297	161	222	116	161	25	663
30	400	420	514	307	326	420	228	243	326	177	243	127	177	30	725
35	432	453	554	332	352	453	246	262	352	190	262	137	190	35	783
40	462	484	593	355	376	484	264	280	376	204	280	146	204	40	837
45	490	514	630	377	399	514	280	297	399	217	297	155	217	45	888
50	516	542	664	398	420	542	294	313	420	228	313	164	228	50	936
55	541	568	696	416	440	568	308	328	440	239	328	172	239	55	982
60	565	594	726	434	460	594	322	343	460	250	343	179	250	60	1,026
65	588	618	756	452	480	618	336	358	480	260	358	186	260	65	1,067
70	610	641	784	470	498	641	348	371	498	270	371	194	270	70	1,108
75	632	663	812	486	515	663	360	384	515	279	384	201	279	75	1.147
80	652	685	...	502	532	685	372	397	532	288	397	208	288	80	1,184
85	672	706	...	518	548	706	383	409	548	297	409	215	297	85	1,221
90	692	727	...	533	564	727	394	421	564	306	421	221	306	90	1,256
95	712	747	...	547	579	747	405	432	579	314	432	227	314	95	1,290
100	730	766	...	561	594	766	416	443	594	322	443	232	322	100	1,326
110	766	806	...	588	623	806	436	465	623	338	465	243	338	110	....
120	800	...	...	614	651	...	456	486	651	354	486	254	354	120	....

If diameter of outlet is not exactly 2½ inches an additional correction, as follows, must be made:

Diameter.	Add.	Deduct.
2⅝	10%	...
2 9-16	5%	...
2 7-16	...	5%
2⅜	...	10%
2¼	...	19%

Notes.—The foregoing values are based on experiments with these kinds of hose attached to a Chapman 4-way independent gate hydrant (coeff. disch. by expt. 0.71). So far as influence of kind of hydrant upon discharge is concerned, the same values are correct enough for practical purposes, except as noted in margin of columns.

It will be noted that this table gives, for each length, the discharge through the best or smoothest hose, and gives, also, discharge for same length of hose with roughest waterway. By use of a little judgment in interpolating between these two values, error in ordinary use of table need not exceed 10 per cent.

Discharge of Water from Grinnell Glass Disc Sprinkler.

(Orifice ½ inch in dia. cut in thin plate).

Pressure at Sprinkler in Pounds per Square Inch, with Water Flowing.	Discharge in Gallons per Minute (Approximate).
2½	8½
5	12
10	17½
15	21½
20	25
30	30
40	35
50	40
75	50
100	58

Metal disc Grinnell discharges about 10 per cent. less.
Walworth discharges from 5 to 10 per cent. more.
Esty discharges about 20 per cent. more.

EFFECTS OF TEMPERATURE.

Cast Iron melts, Morveau	3 696	degrees Fah.
Brass melts, Daniell	1,869	"
Zinc begins to burn, Daniell	941	"
" melts 793 Gmelin, Daniell	648	"
Mercury boils, 644 Daniell, Graham	662	"
Pure Lead melts, 612 Parkes, Daniell	609	"
Linseed Oil boils	600	"
Tin melts	442	"
Oil of Turpentine boils, Kane	315	"
Sulphur melts, 232 Turner, Fownes	226	"
Water begins to boil in glass 213.5 or	213	"
Water boils in metal, barometer at 30 inches	212	"
Alcohol, sp. gr. 0.796 to 0.800, boils	173	"
Phosphorus melts	99	"
Ether, 0.720 boils	96	"
Water freezes	32	"
Mercury freezes	-39.40	"

CONDUCTIVITY, HEAT AND ELECTRICAL.

(Sci. Am. Reference Book).

SUBSTANCES.	Heat Conductivity.	Electrical Conductivity.
Silver	100.0	100.0
Copper	73.6	73.3
Gold	53.2	58.5
Brass	23.6	21.5
Zinc	19.9	....
Tin	14.5	22.6
Steel	12.0	....
Iron	11.9	13.0
Lead	8.5	10.7
Platinum	6.4	10.3
Palladium	6.3	....
Bismuth	1.8	1.2

Fireproofing Paints.—Various substances have been proposed as fireproof coatings for the protection of woods employed for building purposes, but most of them have been abandoned as being either too costly or not sufficiently durable. The following, invented by Vilde & Schambeck, seems to succeed. The paint consists of 20 lbs. finely pulverized glass, 20 lbs. finely pulverized porcelain, 20 lbs. any sort of stone in powder, 10 lbs. calcined lime and 30 lbs. water glass (silicate of soda), such as usually found in commerce. The solid elements, having been powdered as finely as possible and sifted, are moistened and then intimately mixed with the water glass. This yields a mass of syrupy consistency that may be employed for painting either alone or mixed with color. The addition of lime gives a certain unctuosity to the mass for whitewashing, and its combination with the silicic acid of the soluble glass serves to bind the other materials together. The coating is applied with a brush, as other paints are, as uniformly as possible over the surface to be protected. The first coat hardens immediately, and a second one may be applied six hours or more afterward; two are sufficient. (La Papeterie.)

TEMPERATURE OF STEAM AT VARIOUS PRESSURES.

Atmospheric Pressure 14.7. Degrees in Fah. Scale.

Press. per Sq. In.	Deg. of Temp.	Press. per Sq. In.	Deg. of Temp.	Press. per Sq. In.	Deg. of Temp.	Press. per Sq. In.	Deg. of Temp.
1	216.3	12	244.3	32	277.0	80	323.9
2	219.4	14	248.3	34	279.6	85	327.6
3	222.4	16	252.1	40	286.9	90	331.1
4	225.2	18	255.7	45	292.5	95	334.5
5	227.9	20	259.2	50	297.8	100	337.8
6	230.5	22	262.5	55	302.7	105	341.0
7	233.0	24	265.6	60	307.4	110	344.0
8	235.4	26	268.6	65	311.8	115	347.0
9	237.7	28	271.5	70	316.0	120	350.0
10	240.0	30	274.3	75	320.0	125	352.8

Steam flows into the atmosphere at the rate of 650 feet per second.

TEMPERATURE SCALES.

Equivalent Degrees in Fahrenheit, Centigrade and Reaumur,

Fah.	C.	R.	Fah.	C.	R.
—20	—28.8	—23.12	45	7.22	5.77
—15	—26.11	—20.88	50	10.	8.
—10	—23.33	—18.66	55	12.78	10.22
— 5	—20.55	—15.33	60	15.56	12.44
Zero	—17.77	—14.22	65	18.34	14.66
5	—15.	—12.	70	21.12	16.88
10	—12.22	— 9.77	75	23.90	19.10
15	— 7.33	— 7.55	80	26.68	21.32
20	— 6.66	— 5.33	85	29.46	23.54
25	— 3.88	— 3.11	90	32.24	25.77
30	— 1.11	— .88	95	35.02	28.
32	0.	0.	100	37.80	30.22
35	1.66	1.33	105	40.58	32.44
40	4.44	3.55	110	43.36	34.66

B. & S. WIRE GAUGE IN DECIMAL PARTS OF AN INCH.

No.	Size.	No.	Size.	No.	Size.	No.	Size.
0000	0.64	6	0.16202	15	0.05706	24	0.0201
000	0.40964	7	0.14428	16	0.05082	25	0.0179
00	0.3648	8	0.12849	17	0.04525	26	0.01594
0	0.32495	9	0.11443	18	0.0403	27	0.01419
1	0.2893	10	0.10189	19	0.03589	28	0.01264
2	0.25763	11	0.09074	20	0.03196	29	0.01125
3	0.22942	12	0.08081	21	0.02846	30	0.01002
4	0.20431	13	0.07196	22	0.02534	31	0.00893
5	0.18194	14	0.06408	23	0.022511	32	0.00795

BAROMETRIC PRESSURE AT DIFFERENT ALTITUDES, WITH EQUIVALENT HEAD OF WATER.

Altitude.	Barometric Pressure.	Equivalent Head of Water.
Sea level	14.70 lbs. per sq. in.	33.95
¼ mile (1320 ft.) above sea level	14.02 " "	32.38
½ " (2640 ft.) " "	13.33 " "	30.79
¾ " (3960 ft.) " "	12.66 " "	29.24
1 " (5280 ft.) " "	12.02 " "	27.76

SIZES OF SAFETY OR RELIEF VALVES.

For 320 Gallon Pump	2½ Inch Ashton Valve (or equivalent.)
" 500 "	3 " " "
" 750 "	3½ " " "
" 1000 "	4 " " "
" 1500 "	5 " " "

CHAPTER XVIII.

HAZARDS.

The general hazards of constructional faults, heating, lighting and exposures, obtain in all classes of risks.

The following special risks have, in addition to the general hazards, the specific hazards as noted:

ACID WORKS.—Hot gas conveyors, empty nitrate of soda bags.

ALCOHOL DISTILLERIES.—Alcohol fumes.

BLEACHERIES AND DYE WORKS.—Singeing, hot or dry rooms, drug rooms, chemicals, roller cleaning.

BREWERIES—Heating of kettles, pitching kegs, malt mills, kilns, dust.

BRUSH FACTORIES.—Pitching.

CELLULOID FACTORIES.—Highly inflammable nature of celluloid and similar compounds, made mostly of gunpowder and camphor.

CORDAGE WORKS.—Stock, dust, oil, tarring.

COTTON GINS.—Foreign materials passing through gins, striking sparks in the loose lint.

CURRYING SHOPS.—Board scrapings.

DYEING AND CLEANING.—Usually benzine, naphtha, gasolene or some such volatile liquid used.

FERTILIZER WORKS.—Fish scraps, green bone mills, lampblack, nitrate of soda bags, driers.

FLOUR MILLS.—Friction of machinery, explosive dust, frictional electricity, heaters, conditioners.

FUR HAT FACTORIES.—Dust, alcohol, drying, singeing.

FURNITURE, CABINET, WAGON, CARRIAGE, CASKET FACTORIES.—Dust, conveyors, vault, kilns, caul boxes, paints, oils, varnishes, dry rooms.

GRAIN ELEVATORS.—Shafting supported on bin work, choking in elevator heads, dust from smut and brush machines, corn shellers, uncovered oil cups.

METAL WORKERS.—Cupola stacks at roof and feed platform, gases in core ovens, benzine, naphtha for cleaning, lacquers, japans, paints, dry rooms, dust from polishing wheels, oily metal cuttings, oily waste, ovens.

OIL CLOTH FACTORIES.—Benzine and naphtha, coating room, dry room, paints, oils.

PAPER MILLS.—Rag cutters, dusters, drying, straw, low grade rags.

PORK PACKERS.—Barrel stoves, lard rendering, smoke house.

PRINTING; LITHOGRAPHING.—Benzine, "broke," lampblack, waste paper.

PULP MILLS.—Chippers, digesters.

ROPE WORKS.—Tarring, dust, raw stock.

RUBBER WORKS.—Mixing and making rooms, vulcanizers, driers, benzine and other volatile liquids and cements, reclaiming, devulcanizers.

SHOE FACTORIES.—Cutting block scrapings, dressings, kit lamps, waste chutes, cements and volatile liquids, turpentine.

SUGAR REFINERIES.—Char house, kiln, bag storing and drying.

SULPHITE PULP MILLS.—Sulphur, digesters.

TANNERIES.—Bark mill, dust, fleshings, hair batteries, oil, grease, whitenings, lampblack, lime, drying, varnish and ovens (enameling works).

TEXTILE MILLS—Cotton and Woolen.—Openers, pickers, cards, lint, dust, napping lint, dryers, carbonizing, shoddy (woolen mills).

VARNISH WORKS.—Boiling and mixing.

WOOD WORKERS.—Dust, conveyors, vaults, kilns, dry rooms, caul boxes, waste burners, refuse and waste, sparks from stacks.

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